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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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VOL. CXIV.—No. 2962.] *LONDON: FRIDAY, OCTOBER 6, 1922.* [*Registered at the General Post Office as a Newspaper.*] [PRICE — 1s. BY FOREIGN POST 1s. 4d.

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See Illustrated Advertisement Page 29, Sept. 29.

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See Full Page Advt., page 63, Sept. 15.

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See half page advert., page 39, Sept. 29.

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See Advertisement page 57. 9052

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See half-page Advertisement page 97, Sept. 29.

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By Order of the Board,
F. S. SPIERS,
Secretary.
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Tenders (by telegraph) to reach New Zealand by 9th inst. W 452

BENGAL-NAGPUR RAILWAY COMPANY LIMITED.

The Directors are prepare to receive

Tenders for the following:— WHEELS AND AXLES.

Specification and Form of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad Street, London, E.C. 2, on or after 2nd October, 1922.

A fee of £1 1s. will be charged for the Specification, which will not be returned.

Tenders must be submitted not later than Noon on Monday, 16th October, 1922.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
T. R. WYNNE,
Managing Director. W 442

EAST INDIAN RAILWAY.

The Directors are prepared to receive, up to Eleven o'clock a.m.,

Tenders for the Supply of:—

(1) BRASS BOILER TUBES and COPPER PIPES,
(2) COPPER FIREBOX PLATES,
(3) LOCOMOTIVE BOILERS, &c.

for Nos. 1 and 2 on Wednesday, the 18th October, instant, and for No. 3 on Wednesday, the 25th October, instant.

Copies of the Specifications can be obtained at the Company's Offices on payment of £1 1s. This fee will not be returned.

G. H. LILLIE,
Secretary.
73-76, King William Street, London, E.C. 4.
4th October, 1922 W 471

GREAT NORTHERN RAILWAY (IRELAND).

TENDERS FOR SWITCHES.

The Directors are prepared to receive

Tenders for Switches, in accordance with the Company's Drawing and Specification, copies of which may be obtained from the undersigned.

Tenders made out on the forms supplied by the Company, should be delivered, under sealed cover, endorsed "Tender for Switches," not later than Ten a.m., on Monday, October 23rd.

The Directors do not bind themselves to accept the lowest or any Tender.

J. B. STEPHENS,
Secretary.
Amiens Street Station, Dublin,
3rd October, 1922. W 474

ENGINEERING WORK.

Firms Desirous of Tendering for SMALL REPETITION WORK in large quantities, can have particulars of same by applying to:

W. S. MUNDLE, Engineer, Glasshouse Lane, Gateshead-on-Tyne. Fee 15/6 (to cover cost of Drawings), not returnable. W 397

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For Disposal Six E. Type STOKERS by the Underfeed Company, each having a grate area of 64 sq. ft. The Stokers are part of large boiler plant purchased from the Disposal Board and are only offered for sale owing to the heating surface of boilers being increased on re-installation.

Stokers have only had about 12 months' service and are in excellent condition.

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Offers to be sent to:—

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Electricity Works,
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TWO WOODSON PATENT WATER TUBE BOILERS, superheaters and hand fired furnaces now lying at Thornhill Power Station. Capacity of each boiler 25,000 lb. of water per hour from and at 212° F. At present insured for a working pressure of 200 lb. per square inch. Heating surface 4670 square feet. Complete with Hopkinsons mountings and Superheat Furnace Company's Grates of 90.5 square feet area.

These are in first-class condition and have only been removed to provide space for larger units.

The boilers will be dismantled by the Company but it is desired that they should be loaded and removed by the Purchaser; Also

ONE CONDENSING PLANT, consisting of a Surface Condenser, made by the British Westinghouse Company. Cooling surface 4400 square feet, weight 10.5 tons, now lying at Barugh Power Station, and a

Rees Roturbo CIRCULATING PUMP and Le Blanc AIR PUMP on one shaft driven by 90 B.HP. Westinghouse Turbine.

ONE 18 in. bore atmospheric exhaust valve.

ONE 48 in. bore copper expansion joint.

This plant was installed in 1913, is in good condition and has been displaced by a larger unit.

FOR PERMISSION TO VIEW, and further details apply to:—

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Tenders are Hereby Invited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.

Copies of Tender Form and Specification will be available on and after 21st September, 1922, upon application to:—

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The Specifications may be inspected at the above-mentioned office.

The Commission does not bind itself to accept the lowest or any Tender.

Tenders on prescribed forms, properly endorsed and addressed, must be delivered to the undersigned in Melbourne not later than Five p.m. (in the case of Specification No. 306), 31st January, 1923, and (in the case of Specification No. 317) 15th January, 1923.

R. LIDDELOW,
Secretary.
State Electricity Commission of Victoria, Melbourne, Victoria, Australia. W 355

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Required in January, 1923, a TEACHER of TECHNICAL DRAWING (Engineering). Graduate preferred. Burnham Technical Scale.

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Wanted, by Corporation Electricity Department in the North of England, POWER HOUSE SUPERINTENDENT, with experience of modern three-phase and Boiler House Plant, and competent to obtain and maintain economical results and the tabulation thereof.

Present salary on N.J.B. Schedule at the rate of £523 per annum.

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Address, W 460, Offices of Engineering.

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THE LITTLETON RESERVOIR FOR THE METROPOLITAN WATER BOARD.

IN recent issues of ENGINEERING* we gave descriptions of the new service reservoirs which the Metropolitan Water Board had brought into commission lately. We now propose through the courtesy of the Board's chief engineer, Mr. H. E. Stilgoe, to describe the largest single enterprise which the Board has on hand at the present time.

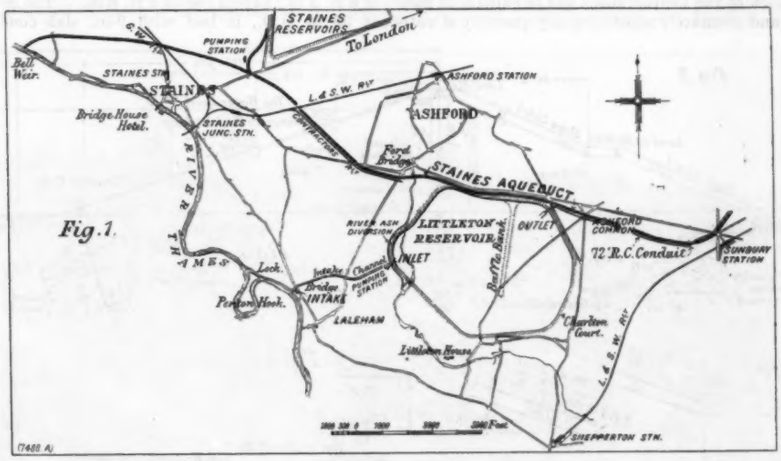


Fig. 1.

We refer to the Littleton Reservoir, the construction of which, like other major work, has been considerably delayed by the war. The Littleton site was first selected when the Board promoted its Works Bill in 1911, the situation being suitable in relation to the Thames, and also to other works of the Metropolitan Water Board. Actually the contract for the work was let in 1914, and some progress was made until 1916, when work was suspended by order of the Ministry of Munitions, who commandeered the plant. The contract was subsequently terminated, and the scheme remained in abeyance until 1919, when a fresh contract was made. The work is now well advanced.

The Littleton reservoir will have a water surface of about 723 acres and a capacity of approximately 6,750,000,000 gallons. This is supposed to represent the largest storage reservoir of its kind ever constructed. The site of this important work is shown in Fig. 1, which will give a clear idea of its relation to Staines and Sunbury, and to the existing Staines reservoirs. The water, which will be drawn from the Thames, will be used to supplement supplies to both North and South London. Part of the supply will be discharged into the existing Staines Aqueduct, which passes close to the north side of the new reservoir. The remainder will be led in the direction of Kempton, where part will be drawn off at the Board's works there for the supply of existing reservoirs and filters and of new filters installed there. This supply will be delivered to the north of London. Beyond Kempton Park one conduit from Littleton will carry water to the Hampton water works, for filtration and distribution.

A larger scale plan of the new reservoir is given in Fig. 2, annexed. This shows the intake on the Thames, where Venturi meters will be fitted, the pumping station and inlet, the baffle bank and outlet, and the general line of the main embankment. When filled the water level of the reservoir will be 75·0 O.D., while the level of the top of the embankment will be 81·0 O.D. Originally the plan of the reservoir covered ground extending rather further west, and not so far south as shown in Figs. 1 and 2. Two baffle banks were also included with the idea of securing good circulation. When the present contract was well under way, however, it was found that it was advisable to modify the form of the reservoir to some extent. The main embankment is being constructed of earth with a core of puddle clay carried down and tied into the London clay, which extends over the whole area below the top alluvial deposits which consist of good ballast of a quality suitable for concrete. On the western side of the original lay-out, however, it was found that a greater depth of running sand than was originally contemplated existed above the London clay, on the line of the puddle trench. It was consequently decided to set back this side towards the east, and carry out an extension towards the south so as to maintain the requisite capacity. Powers were obtained for this, and the lay-out took the form shown in Fig. 2. As a result of this modification it became necessary to provide only one baffle bank to deflect the flow of water from a direct course between the inlet and outlet. This would naturally have been placed approximately in the centre of the reservoir, but as the banks originally planned were already under construction, it was decided to retain one

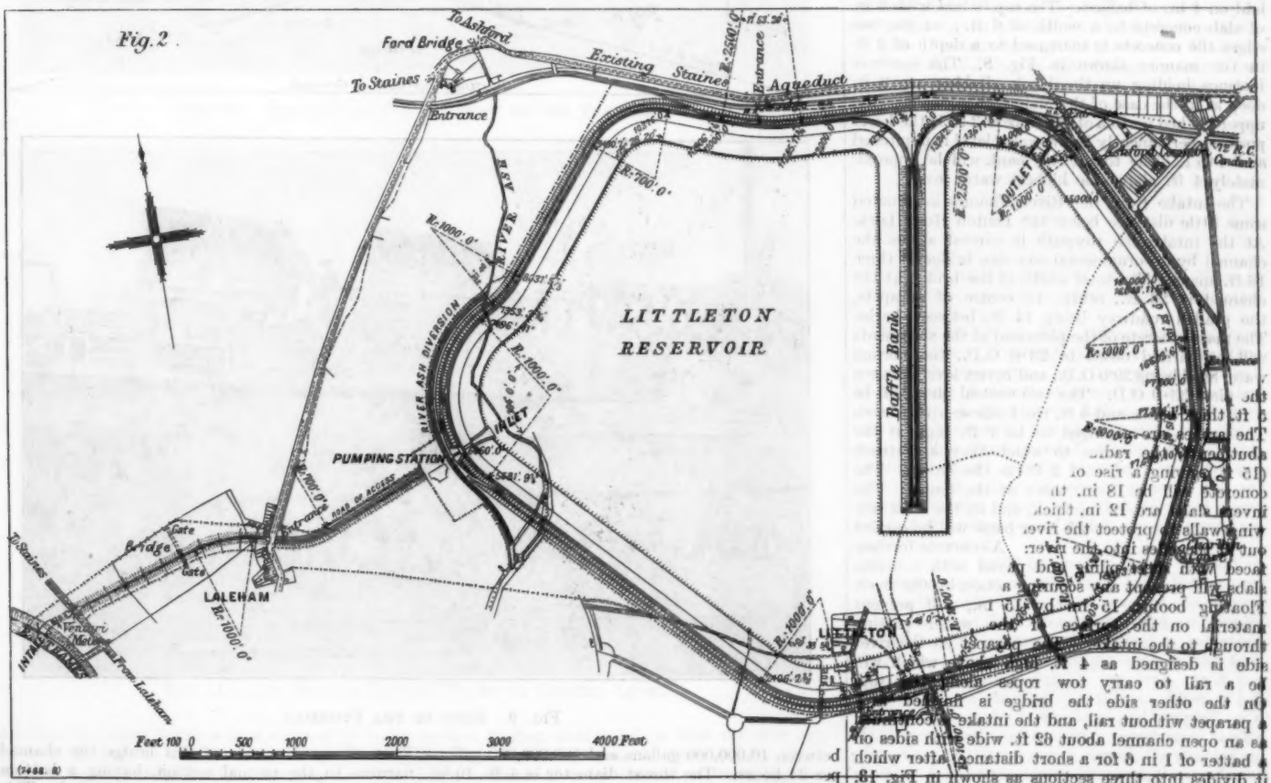


Fig. 2.

* Vol. cxiii, pages 612 and 648.

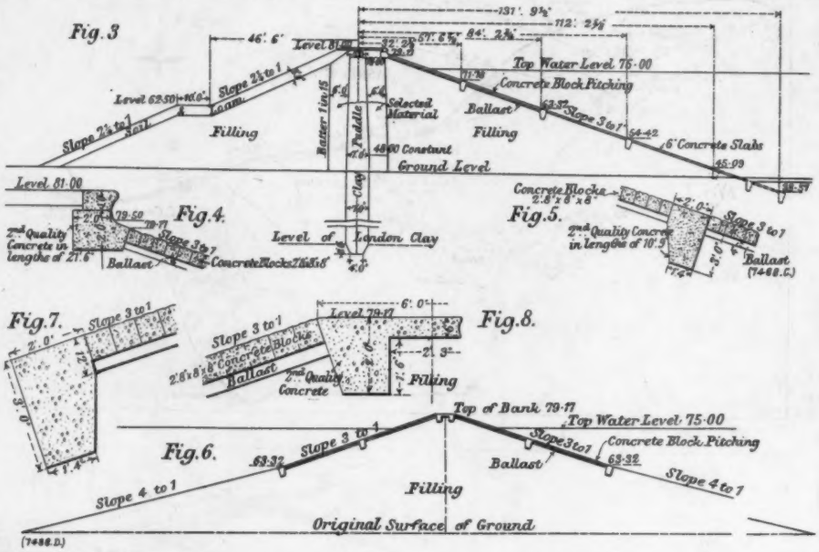
the embankment is 3 : 1, and on this side it is faced with slabs and block pitching. Slab facing is carried from 63·32 O.D. down to 38·57 O.D., that is 4 ft. below normal ground level, the bottom of the reservoir being at 37·0 O.D. The slabs are 6 in. thick and are held in place on the slope by keys or footings of concrete 3 ft. deep by 1 ft. 4 in. at the bottom, and 2 ft. wide at the upper surface. The upper part of the slope as shown is faced with concrete blocks, 2 ft. 8 in. long by 8 in. by 8 in., laid on 4-in. of ballast, the vertical joints between blocks being broken and left ¼ in. wide. This blocking is also held in place by similar footings, a detail being shown in Fig. 5. The coping, a detail of which is given in Fig. 4, is of concrete and is finished with a reversed curve to throw back waves. The width of the bank at the top is 14 ft. The outside slope is 2½ to 1, a 10-ft. berm running round the whole at 62·5 O.D. level. The outside slope is finished with 3 ft. of loam, and will be grass covered and planted with shrubs. Figs. 9, 10, and 11 give an idea of the work connected with the puddle trench, most of which has been excavated by grab bucket. Fig. 9 shows part of the battery of pug-mills, the clay being brought to the elevated platform in side-dumping cars, passed through the mills and shovelled into other trucks on a lower level. Fig. 10 shows the unloading of the puddle at the trench, blocks of clay being slid down chutes to be stopped by a man standing on a baulk spanning the trench. Fig. 11 shows the trench filled to ground level.

Details of the baffle bank are given, as already stated in Figs. 6 to 8. This wall has no core and consists simply of earthwork protected for the upper portions of the slopes by concrete block pitching laid on 4 in. of ballast. The top is laid with 6 in. of slab concrete to a width of 6 ft.; at the two edges the concrete is increased to a depth of 2 ft. in the manner shown in Fig. 8. The concrete footings holding up the block pitching are 3 ft. deep as in the case of the main embankment. The upper pitched portion of the slope is 3 to 1, the lower portion, permanently below water level is unpitched and 4 to 1. The top of this bank will be approximately 4 ft. above the highest water level.

The intake from the River Thames is situated some little distance below the Penton Hook Lock. At the intake the towpath is carried across the channel by an ornamental concrete bridge of three 18-ft. spans. The total width of the bridge at the channel is 28 ft., centre to centre of parapets, the graded roadway being 14 ft. between kerbs. The mass concrete of the piers and at the abutments will be carried down to 23·0 O.D., the normal water level being 39·0 O.D., and invert level between the piers 33·0 O.D. The two central piers will be 5 ft. thick below and 4 ft. thick above invert level. The arches are arranged to be 7 ft. high at the abutments, the radius to which they are struck (15 ft.) giving a rise of 3 ft. to the crown. The concrete will be 18 in. thick at the crown. The invert slabs are 12 in. thick, and on the river side wing walls to protect the river bank will be carried out at the sides into the river: A concrete forebay faced with sheet piling and paved with concrete slabs will prevent any scouring action by the river. Floating booms, 15 in. by 15 in., will prevent material on the surface of the water passing through to the intake. The parapet on the river side is designed as 4 ft. high above which will be a rail to carry tow ropes along the top. On the other side the bridge is finished with a parapet without rail, and the intake is continued as an open channel about 62 ft. wide with sides on a batter of 1 in 6 for a short distance, after which it divides into three sections as shown in Fig. 13, Plate XXXII. At this point are arranged the screens, sluices and Venturi tubes for the control and measurement of the flow from the river. Other drawings of this part of the work are given in Figs. 12 to 17 inclusive, Plate XXXII, the first being a sectional elevation and the others cross-sections at various points. Commencing at the left-hand end of Fig. 12, or entrance, which is floored with 8-in. concrete and has 6 : 1 sides lined with concrete and granite blocks set in mass concrete (Fig. 14), the screens are first encountered. These are arranged in two tiers as shown in Fig. 12, the tops of the lower set and feet of the upper set being fixed in light concrete beams supported by short piers, as shown in Fig. 14. Behind these are arranged roller sluices by Messrs. Ransome and Rapier, Limited, of Ipswich, having openings 12 ft. wide about 6 ft. in the vertical direction. Beyond the sluices each open channel terminates in a 30-ft. length of 9 ft. conduit leading to a large Venturi meter, as shown in Fig. 13. The level of the bottom of these conduits is 25·0 O.D., the level of the sluice sills being 33·0 O.D.

Each of the Venturi tubes will be capable of passing and accurately registering any quantity of water between 10,000,000 gallons and 100,000,000 gallons per 24 hours. The throat diameter is 4 ft. 10 in. The approach tube is nearly 16 ft. long and the discharge tube over 54 ft. long. The throat and up-stream annular pressure sections, with pressure tubes, recording apparatus, &c., are being supplied by Messrs. George Kent, Limited, Luton, the remaining parts being constructed *in situ*. Fig. 15 shows a section at the mouth of the conduits leading to the meter tubes. Fig. 16 gives a cross-section through the well in which the float pipes and the pressure pipes for the recording apparatus, are placed, the actual instruments being arranged close together side by side. The arrangement of this well will be clear from Figs. 13 and 16. Beyond the throat the discharge tube gradually enlarges till it terminates at the roller sluices shown at the right hand of Figs. 12 and 13, and in Fig. 17. These sluices are also by Messrs. Ransome and Rapier, Limited.

Beyond these sluices the channel of 60 ft. width narrows in for a bridge of two 12-ft. spans carrying the road from Laleham to Staines. This bridge is of concrete; the parapets, facing of arches, and the piers and abutments above water level being of Cornish granite. The two arches, struck with a radius of 6 ft. 3 in., have a rise of 4 ft. 6 in. The invert, at 33·25 O.D., is laid with 9-in. slab concrete. From the eastern side of this bridge the channel narrows to the normal section, having a bottom width of 15 ft. and sides sloping 1½ to 1. This channel is lined along its bottom and sides with concrete blocks, 2 ft. 8 in. long by 8 in. by 8 in., i.e., blocks similar to those employed on the main embankment, &c. Except at one point the channel continues at this width up to the covered basin forming the suction tank for the pumps at the pumping station. The one point referred to is where the Ashford-Laleham-road crosses the channel where there is a second two-span concrete bridge similar to that on the Laleham-Staines-road described above. Another bridge is situated between these two, namely an occupation bridge of



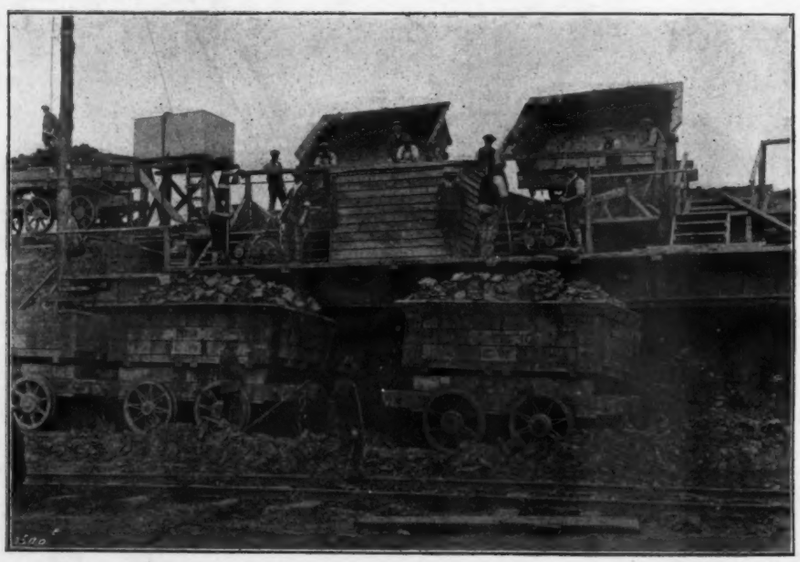


FIG. 9. SOME OF THE PUGMILLS.

30 ft. span, of reinforced concrete, and 12 ft. width between kerbs. This single arch has a rise of 6 ft., the arch being struck with a radius of 21 ft. 9 in. The bridge rests on mass concrete abutments. The reinforced concrete is 10 in. thick at the crown, the bottom main reinforcing bars being in. diameter and 6 in. apart, the top bars being of the same size and 12 in. apart.

At the pumping station, of which we shall give particulars in a subsequent issue, the intake channel widens out to form a basin 40 ft. wide. Here screens are arranged in front of an opening which tapers sideways in a short distance to a width of 20 ft. by 14 ft. 9 in. deep to maximum water level, which extends for a distance of 94 ft., forming a covered suction basin. The floor of this basin is at 24·25 O.D. and the sill level at the screens 31·42 O.D. The suction chamber extends alongside the pump-house, and is covered with slab concrete, 6 in. thick, supported on concrete beams, 5 ft. 9½ in. centre to centre, and 1 ft. 7 in. deep by 9 in. wide.

The suctions for the four pumps for lifting the water from this basin into the reservoir lead off at an angle of 45 deg. and, commencing with a conduit 7 ft. 6 in. diameter, reduce to a parallel length of 6 ft. diameter by means of a bell mouth 3 ft. 9 in. long. The 6-ft. pipe is 14 ft. 7½ in. long when a gradually tapering length of 13 ft. reduces to 5 ft. diameter. At this point steel bends continue the suction up to the pumps in the engine-house. The pumps are single-stage centrifugals direct driven by Uniflow engines, the contract for this machinery being in the hands of Messrs. Worthington, Simpson, Limited, of London. Each pumping set will be capable of delivering 75,000,000 gallons per 24 hours against a head of 37 ft.

The four rising mains leave the pump-house at an angle of 45 deg., that is at right angles to the suctions. They are each 5 ft. in diameter, and each at a suitable distance outside the building turns with a 45 deg. steel bend, so that the four pipes run thence parallel to one another at 9 ft. centres. They continue thus the short distance to the main embankment over which they will be carried in the manner shown in Figs. 18 and 19, Plate XXXI, sundry details of this part of the work being given in Figs. 20 to 24. Just outside the embankment the pipes pass under a small river diversion, and they are then carried to the top of the bank on a slope of 2½ to 1. At the top the pipes are horizontal for nearly 28 ft. at an elevation of 78·0 O.D. On the inside of the embankment the slope of the pipes is 2 : 1, and they terminate in a basin formed by a concrete wall 8 ft. high, the top of the pipes being rather more than a foot below the weir. At the point where they cross the bank the pipes are carried on a mass concrete structure formed of a series of six arches, the spaces between the piers being filled in with earth. The puddle core divides the structure into two parts. The piers are 5 ft. thick and the inverts 3 ft. The pipes are carried on saddles of concrete monolithic with the arch structure.

The discharge basin is 50 ft. in width by 30 ft. long to the foot of the weir. The latter is 12 ft. thick, and beyond it is a small weir 2 ft. high to break up the wave. Over this the water flows on to a large slab concrete apron at 37 O.D. level, gradually expanding in width, with curved sides, till at a distance of 341 ft. from the centre of the puddle core, it ends with a width of 155 ft. 7½ in. The slabs for this apron are 15 ft. by 10 ft., and vary in thickness from 15 in. near the basin to 6 in. at the wide end.

(To be continued.)

FIG. 10. DELIVERY OF PUDDLE CLAY TO THE TRENCH.

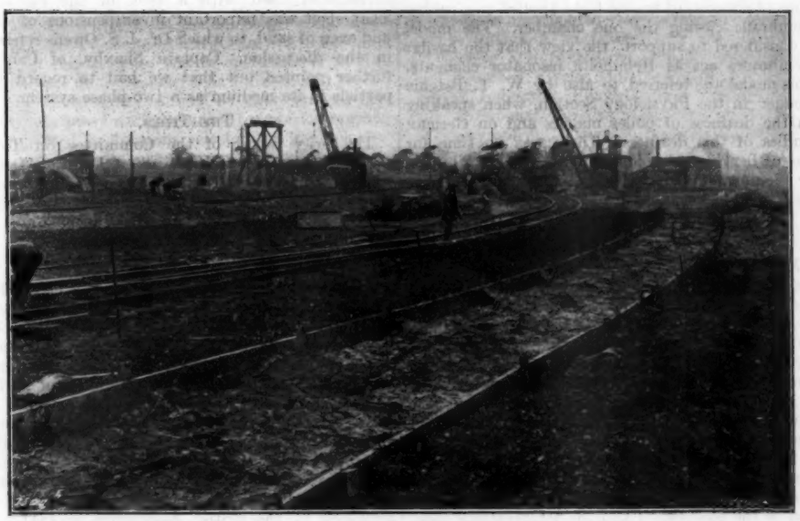


FIG. 11. THE PUDDLE TRENCH FILLED TO GROUND LEVEL.

THE BRITISH ASSOCIATION.

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

(Continued from page 391.)

PHYSICAL INSTRUMENTS FOR BIOLOGICAL PURPOSES.

THE joint discussion with Section I, Physiology, on "Physical Instruments for Biological Purposes," under the chairmanship of Professor L. P. Cathcart, F.R.S., of Glasgow, president of I, may be regarded in some respects as emphasising the need of a journal dealing exclusively with matters relating to scientific instruments and in which instrument-makers, physicists and physiologists could respectively specify the problems with which they desire to deal. In introducing the discussion Professor A. V. Hill, F.R.S., of Cambridge, pointed out that the working unit, the living cell, was excessively small, that phenomena occurred in it with extreme rapidity, in a manner totally different from ordinary "common-sense" physical conceptions, and that the living organism was too sensitive to external conditions to suit physical methods of study. If it were not for the difficulties of satisfying this third statement, the deviations from "common-sense conceptions" might possibly be less obvious. Professor Hill proceeded to outline some mysterious physico-chemical problems. Most of the scientific appliances subsequently mentioned were on exhibition.

Major W. S. Tucker, R.E., of the Signals Experimental Station, Woolwich, the next speaker, then dealt with apparatus for the production and measurement of vibrations as used in the Acoustical Laboratory set apart for the Anti-aircraft and other Service Departments. For acuity testing, he pointed out, devices were needed giving reproducible sounds of great purity, uniform intensity and variable pitch, since the sensitiveness of the ear varied with the pitch, and that involved great physical difficulties—with which our comments are mainly concerned.

Pure sounds could be produced with the aid of Helmholtz resonators, cylindrical brass bottles provided with cylindrical necks, excited by tuning forks. He found that beyond certain fork-amplitudes the Helmholtz instruments acquired a saturated condition, a change of 100 per cent. in the fork vibratory producing only 2 per cent. or 3 per cent. change in the neck vibrations. When a hot wire was inserted in the neck and coupled in a Wheatstone arrangement with a transformer having a telephone in the secondary circuit, the diaphragm of which formed the source of sound, it was found that for extreme limits of acuity the hot wire was only 1 deg. or 2 deg. C. hotter than the air; but the hot wire interpreted a note which was not pure, containing some harmonics (chiefly the octave). In another mode of excitation, used by Captain Paris for standard sources of sound, the diaphragm vibrated by acoustic oscillation formed the base of the resonator, and the hot wire microphone in the neck merely served to measure the energy of vibration. The Helmholtz resonator acted as a filter for the partial overtones, and the ear could be tested without the use of a subsidiary telephone diaphragm which, at the present time, could not be made into

a standard instrument. The other method of producing pure sounds was due to Mr. F. E. Smith, who would himself explain it.

Referring to paracusis—the dubious ability of deaf people to hear better in noisy railway carriages than in quiet rooms—Major Tucker mentioned that in such tests, a loud sound of uniform intensity was superposed upon the telephone diaphragm used, and the signal was made and broken while the sound remained continuous; that required a silent Morse key which, vibrating between rubber stops, tilted a mercury column so as to make contact between two platinum wires. The hot wire was utilised—in addition to thermoionic valves, Einthoven galvanometers and other devices—also for recording breathing and pulse movements and body recoil. People standing quite still on a weighing machine wondered why the indicator oscillated; that was owing to the breathing and the pumping of the heart, and was observed by pressing diaphragms gently against the body. The grids (thermophones) of very fine hot wires used in these apparatus were insensitive to rapid vibrations (above 500 per second, *e.g.*,) and most sensitive when the direction of the air currents resulting from convection was the same as that of the vibrating particles. The periodic resistance changes in the hot wire tended to give the octave of the note if the convection currents of the grid were perpendicular to the vibrations in the air, but tended to a pure reproduction of the air disturbances (due to the pulse, &c.), if the convection currents were parallel to the displacement of the air particles.

Mr. F. E. Smith, F.R.S., director of Scientific Research at the Admiralty, then described his magnificent set of apparatus which he stated he had developed together with Mr. H. C. Napier. No instrument was as sensitive as the ear, which could perceive pressure differences of 10^{-5} *erg* in form of oscillations at 800 periods per second. The frequency of the ordinary conversational voice was only about 150. Absolute acoustic measurements could be based upon combinations of thermal, electric and piezo-electric methods, as Mr. Smith demonstrated. In Rayleigh's method a mirror was suspended at 45 deg. to the longitudinal axis of the system between the collimator of a source of light and the neck of an adjustable Helmholtz resonator, a sliding cylinder the base of which was formed by a telephone diaphragm. In Sir William Bragg's "chattering" apparatus a small ball was suspended in front of a steel diaphragm. In Mr. Smith's own apparatus the current in a triode valve circuit was caused to oscillate at audible frequency, the frequency being variable from 100 to 10,000 by changing the capacity or the inductance or both; to get down to frequency 10 would have required ½ cwt. of inductance, however. The intensity of the current was controlled by varying the filament current. Included in the plate oscillatory circuit of the valve was the primary coil of an air transformer, the secondary of which was connected with a telephone, a thermophone (exceedingly fine wire) or other devices, and the intensity of the oscillatory circuit or the mutual inductance between the transformer coils, or both were varied to render the note inaudible. When the mutual inductance was known, the apparatus would serve as a standard of reference for measurements of acuity; when the amplitude of vibration, or the total energy emitted from the receiving mechanism was known, the apparatus could be used for absolute acuity measurement. The amplitude of vibration was determined by means of a thermophone or a piezo-electric crystal—an American specimen of Rochelle salt (potassium-sodium tartrate) in a box, about 1 in. deep, was used.

Mr. R. Somerville Hastings, M.S., F.R.C.S., then explained how these various devices of Major Tucker and Mr. Smith were replacing the simple but unreliable apparatus so far available. Mr. Smith had indicated how his apparatus could be simplified for definite purposes, and Mr. Tucker showed how he took acuity curves. Paracusis, Mr. Hastings remarked, was simply explained probably by the fact that people talked louder when there was much noise about.

Mr. R. S. Whipple then outlined the main features of various novel instruments, some of which were exhibited as manufactured by the Cambridge and Paul Instrument Company. These comprised an instrument for measuring the carbon dioxide percentage in alveolar air (due to Professor Hill); the simple form of Einthoven string galvanometer with two copper wires, due to Professor Salomonson; hydrogen ion apparatus; the Gamgee body temperature indicators, and several other novelties recently illustrated in our columns. Among chronoscopes for physiologists he mentioned the modification of Hipp's chronoscope—due to Professor Wertheim Salomonson, of Amsterdam, who died a few days after the meeting—a phonic wheel of the Paul la Cour type, fitted with 10 teeth (armatures) and driven by a synchronous motor controlled by a tuning fork; the wheel actuates a counter which records $\frac{1}{10}$ of a second. Messrs. Wood and Ford of the Admiralty Research Laboratory, Mr. Whipple added, had also devised chronoscopes, and he drew attention to the kinematograph camera of L. Bull, of the Marey Institute, Paris. Even with illumination made by the quenched sparks of Cranz and Glatzel, at $\frac{1}{50{,}000}$ second intervals, a film rotating at a speed of 100 m. per second would only yield an image, 2 mm. in depth. In order to obtain larger, yet distinctly dissociated images, Bull kept the cylindrical film stationary and rotated the optical system inside the cylinder, about the longitudinal axis of the cylinder used and of the system. The latter consisted of a lens and a triangular prism, 6 cm. side length, which sent out a radial beam. Thus film speeds of 500 metres per second were obtained when the optical system was turned at 160 revolutions per second, and the sensitivity of the film now set a limit to velocity.

Among other exhibits was the working model of Dr. G. Wilkinson, of Sheffield, illustrating the presumed resonating mechanism of the cochlea. The model consisted of a brass box containing two chambers, which were filled with water and divided by basilar membranes, *i.e.*, flat fine phosphor-bronze wires; the wires were stretched progressively by weights so as to respond to the different vibrations (4 octaves) of tuning forks applied to a rubber membrane closing the one chamber. The model is considered to support the view that the basilar membranes act as Helmholtz resonator elements. This model was referred to also by W. T. Ritchie Rodger in the Physiology Section, when speaking on the deafness of boiler makers and on German studies of this deafness. There was no time for the further discussion in Section A, the contribution by Lieutenant-Colonel Heald, M.D., being taken as read in his absence.

Cathode Luminescence and Molecular Aggregation.

Mr. J. Ewles, of Leeds University, described a series of experiments, on which a great deal of care and thought had evidently been bestowed, made to ascertain whether the luminescence excited by cathode rays is produced by rays of a minimum speed and a definite energy quantum—a highly-controversial problem. The bulb was worked by a Mercedes electrostatic machine, and the volts were controlled by a Kelvin-White voltmeter. The numerous metallic oxides and other substances so far examined all required rays of characteristic speeds, but the luminescence depended, as to intensity and colour, also upon the mode of preparation of the compounds and the temperatures used. Thus zinc oxide gave different luminescences, green to orange, at speeds (expressed in volts) of 580, 650, 710, when prepared by sublimation of a zinc arc or from various salts. Iron oxide flashed red at 4,000 volts and bluish at higher volts; smaller crystals phosphoresced already at 1,000 volts, but when very finely ground they showed no luminescence. This peculiar vanishing of the luminescence with the exceedingly fine grinding was probably not an isolated case.

Alumina, which changed its fluorescence and molecular state at 1,060 deg., zirconium oxide, various silicates and quartz were also tested; quartz was partly converted into tridymite. Mr. Ewles therefore suggested that cathode luminescence was a manifestation of the energy change involved when a substance changed from one state of molecular aggregation to another. By that he meant transformations, such as zinc oxide, *e.g.*, is known to undergo about 700 deg. C., and he further investigated this influence by the aid of differential heating curves. In every case the cathode luminescence vanished when the temperature exceeded the transformation point. Mr. Ewles, who is working under Professor Whiddington, concluded that the cathode rays exciting fluorescence represented the amount of energy required to break up a molecular aggregate; and that the phenomena were not atomic and not chemical. Fluorescent spectra being always banded he hoped to link up this work with the molecular rotation theory of band spectra of Bjerrum.

Distribution of Particles in Colloidal Solutions.

Professor A. W. Porter, F.R.S., of University College, W.C., referred in this paper to Perrin's work. It had recently been pointed out by E. T. Burton that, according to Perrin, the number of colloid particles of gamboge in dilute solutions doubled as the depth increased by 0·003 cm.; if that rate continued we should at a depth of 3 cm. have 2^{1000} (a number of 300 digits) times the number of particles in the top layer. But Perrin's measurements were confined to a surface layer of less than 0·1 mm. thickness, and, as a matter of fact, Professor Porter said, the density curve soon reached with increasing depth (at about 0·1 cm.) a fairly constant value after an initial sharp rise. Perrin had assumed that the laws of a perfect gas would hold for his diluted solution. To pass to more concentrated solutions, Professor Porter had introduced a van der Waals term b (as Weiss had done in his magnetic studies) and he then found that three or four layers might be distinguished. First a surface Willard Gibbs layer, which might have a special value; then the Perrin layer; then a layer which did not conform to the Perrin rule, merging into the main solution of fairly uniform concentration. The b was, however, much larger than that which optical consideration suggested, and that was probably because the actual particle surrounded itself with a shell of the medium. That shell was important in suspensions of clay and even of sand, to which Dr. J. S. Owens referred in the discussion. Captain Shaxby, of Cardiff, further pointed out that we had to regard the particle in its medium as a two-phase system.

The Tides.

The brief report of the Committee on Tides (Professor Horace Lamb, chairman, Dr. A. T. Doodson, secretary) dealt with further investigations carried out at the Tidal Institute, Liverpool, mainly on the harmonic analysis of records and on the physical nature of the variations.

The Tides of the North Sea.

In his very interesting lecture on "The Tides, with Special Reference to the North Sea," Professor J. Proudman, of the Tidal Institute, Liverpool, gave a first preliminary account of important recent researches. At Hull, Professor Proudman said, the spring tides had an amplitude of 20 ft., and the tidal currents reached 5 knots, against 1½ knots in the North Sea. The two tidal gauge stations at Hull and other stations further up the Humber and in the country were mostly owned by companies, whilst they were generally controlled by Governments elsewhere. The first observations published by the British Association in 1841 had been taken by Captain Hewitt in the North Sea by means of lead-lines from anchored ships. The best of the automatic recording gauges for open sea observations was the maréegraphe of L. Favé—who had died the week before the meeting—who placed an instrument fitted with two Bourdon tubes at the bottom of the sea (down to depths of 200 m.) and left it there for a week, obtaining height records correct within 1 cm. probably. His instruments had been used chiefly near the French coasts, but also in the estuary of the Thames, and the tidal phenomena of the North Sea were on the whole the best known. The measurement of horizontal tidal currents was made by floating logs. Eckman recorded the currents by means of a propeller and of a vane, which dropped balls into a compass card to show the direction. All these appliances had to be hauled up at intervals.

Tidal predictions had been based upon the

harmonic analysis of the rise and fall curves and were so far made with the aid of Kelvin's machine of 1866. Showing the Berghaus chart of 1890, Professor Proudman pointed out that the co-tidal lines had been assumed to run fairly west-east across the North Sea, becoming more S-shaped near the Channel. But recent British Association reports had already admitted that the predictions were not reliable for shallow ports. Already before the war H.M. surveying vessels had determined the rise or fall by the pressure required to pump air through india-rubber pipes extending from the ship down to the anchor at the sea bottom; Warburg's revised hydrographic charts of 1919 had been published in 1919. The recent very laborious but promising work was based upon the determination of the tidal currents and their directions at different depths. The water was never at rest at any station. Those observations showed that there were really two amphidromic points—first suggested by Sterneck, but often doubted—at which co-tidal lines from different coasts intersected. The one of these was near the eastern mouth of the Channel, the other off the coast of Norway, somewhere near Stavanger. Others had placed these two points further off Norway and nearer Heligoland. Sterneck's prediction had been merely theoretical. Holzhauer had come nearer the actual spots by his observations and calculations. In calculations we might first disregard both the rotation of the Earth and the friction (astronomical tides) or disregard only the friction. Accepting the latter restriction there should be three amphidromic points and a curved nodal line running roughly north and south, halfway across the North Sea. Professor Proudman explained these very complicated matters with the aid of many diagrams.

Investigation of the Upper Atmosphere.

The report of this Committee (chairman, Sir Napier Shaw; secretary, Mr. C. J. P. Cave) drew attention to the memorandum submitted by the Committee to the International Union of Geodesy and Geophysics, held at Rome in April last. Most of the suggestions made have been approved, and pilot balloon observations are to be extended. For this purpose the co-operation of bodies and private individuals is to be enlisted, and yacht clubs and aero-clubs, as well as astronomical observatories have been approached; some observatories are situated in locations selected for their clear atmospheres, and observations of the stratosphere in such high-pressure belts are particularly desirable. Observations are also to be made from the surveying ship at Bermuda. With regard to the correlation between pressure and temperature, observations have been conducted in Canada (with instruments supplied by Mr. W. H. Dines) and by Dr. van Bemmelen in Java. In Canada high pressure and high temperature go together in summer and low pressure and low temperature in winter, and this is particularly marked at altitudes of 6 km. and 8 km. (coefficient of 0·93), whilst there is no correlation on the surface. In Java the maximum coefficients are less high, but continue to greater heights (12 km. and 14 km.).

Convection in the Atmosphere.

In presenting his views on "Convection in the Atmosphere" Sir Napier Shaw, F.R.S., pointed out that the atmosphere was endowed with a certain stability or vertical resilience in consequence of the normal distribution of potential temperature. Successive layers could slide over one another while preserving their identity, as in a pack of cards but there were three physical disturbing factors. Firstly, eddy currents, due to frictional or viscous forces, carried the surface air, relatively moist normally, upwards, and might cause cloud or drizzling rain. Secondly, there was the flow of air across the isobars on the surface; that flow let down the general mass of air within an anticyclone at the rate of perhaps 80 metres per day, whilst on the other hand piling up air over the area of a cyclone at 80 m. per hour. That process had been regarded as controlled by thermal convection, and therefore pointing to the cause or maintenance of low pressure; but it should be regarded as the natural method of annihilating cyclones which would invariably succeed, if there were not some means of renewing the energy. Thirdly, there was true thermal convection, the lighter air penetrating upward and expanding, aided by the facility of condensing its moisture on cooling; that process might cause sudden heavy rains. Our readers will find some examples of these pillar clouds and convective rainfalls in our brief abstract of Sir N. Shaw's Royal Institution lectures on "Droughts and Floods" (ENGINEERING, March 17 last, page 246). The convection process might be analogous to that of air in water which came up as a multitude of small bubbles. The vertical motion had strong, not fully explored, evictive action and dynamical effects in its rapid ascent, as it carried along many times its own volume of the air through which it travelled.

Recent Developments in Synoptic Meteorology.

In this communication, Mr. M. A. Giblett, of the Meteorological Office, explained the Meteorological Exhibition of daily charts and forecasts held in the Guildhall during the meeting, where data were received by radiotelegraphy from the broadcasting stations in various countries, their reception, decoding and charting being demonstrated by representatives of the Office and the Air Ministry. Mr. Giblett outlined the organisation of the daily International Exchange of Weather Information and the facilities existing for the construction of weather charts in the universities and other educational institutions, laying stress on the value of this work for educational purposes as well as for the appreciation of forecasts. The new International Code embraced the detailed meteorological information as to visibility, cloud type and height, amount and time of rainfall, &c. The lines on which forecasting is progressing he exemplified by referring to the Norwegian school of meteorologists; there the horizontal distribution of temperature and especially the existence of discontinuities figured largely in connection with the growth and subsequent history of atmospheric disturbances.

Weather Cycles. Monsoons.

We can only briefly mention two joint discussions relating to these subjects, the first, held by Section A in conjunction with F (Economic Science and Statistics) and M. (Agriculture), on "Weather Cycles in Relation to Agriculture and Industrial Fluctuations," and the second on "Monsoons," held in conjunction with Section E (Geography). The first discussion, introduced by Sir William Beveridge and continued by Mr. R. A. Fisher of Rothamstead, Professor H. H. Turner, of Oxford, and Dr. G. C. Simpson, director of the Meteorological Office, testified to the very natural liking of meteorologists for periodicities and correlation of sunspots, rainfalls, crops, wheat prices, &c. Many of the correlation coefficients are still low, less than 0·4, as we occasionally suspect from forecasts, and it was satisfactory to hear that Sir William Beveridge withdrew his prediction—if it could be called that—of a famine year like 1315 for 1923. The theory of the Monsoons which Dr. Simpson gave in the second discussion—in which Messrs. W. G. Kendrew, G. G. Chisholm and H. Jeffreys took part—is based upon his studies of the distribution of pressure, temperature, wind during the different seasons, and upon local topical features, among which mountain ranges figure prominently, in India and adjacent countries and over the ocean. On these considerations the local vagaries of the Indian rainfall become intelligible.

Seismological Investigations.

The report of this committee, of which Professor H. H. Turner, F.R.S., of Oxford is chairman, and Mr. J. J. Shaw, of West Bromwich secretary, was presented by Professor Turner. The report refers to the Geophysical Conference, held last May at the Royal Astronomical Society, and to the negotiations as to the seat of the Central Bureau which had been at Strassburg under Hecker. The issue of Bulletins of the Committee from Oxford is being continued. Two Milne-Shaw instruments have been sent to Toronto, two to Victoria (British Columbia) and one to the Eclipse Commission on Christmas Island. The main subjects discussed in the report are the depth of the earthquake focus and the periodicity of small recurring shocks, probably interconnected phenomena. The focus depth used to be considered small, something like 40 km. on an average, but the estimates varied widely, and the late Mr. G. W. Walker and others believed in depths of 0·2 of the earth radius. The Calabrian earthquake of 1905 was supposed to have originated at a depth of 40·5 km., the Formosa earthquake of 1906 at 450 km.

Periodicity estimates differ still more widely, from hundreds of years for some large earthquakes to minutes for small shocks. The Mizusawa shocks of August, 1917, coming apparently from the same focus, recurred at intervals of 21 minutes.

The shortest path for an earthquake wave through the earth would be along a diameter through the focus, the epicentre and anticentre indicating the near and far end of the diameter. Now very laborious examinations of various date Professor Turner said, showed that 21 min. was approximately the time taken by the first P wave to travel right through the centre. The exact period at Mizusawa was 20 min. 17 sec.; the difference of 43 seconds might be a measure of the depth of the focus or of its upper limit.

Mr. J. J. Shaw added that he had made some further observations on microseisms. When his stations were 10 miles apart, his results had become discordant; his recent observations at two stations, 2½ miles apart, not oriented like his former stations, confirmed his previous conclusions, as to which we refer our readers to our comments on page 355 of our issue of September 10, 1920.

The Escape of Molecules from Stellar Atmospheres.

Mr. E. A. Milne, of Trinity College, Cambridge, dealt on novel lines with the much-discussed question, how stars and planets are able to retain molecules of light gases in their atmosphere. If we were near the bottom of a deep atmosphere of opaque molecules, all of the same kind, he said, our sky would appear completely covered with molecules, and from that depth no molecule could escape, since it would collide with others above. When the observer ascended vertically, molecular escape would become possible, first in the vertical direction; the region of partial clearance would then extend round the zenith, and the solid angle ω of partial clearance would ultimately approach 2π. The rate of escape and the critical velocity of the escaping molecules would depend upon various factors, the temperature, pressure, free path of the molecules, the gravitation potential, &c., and chiefly upon the product $\rho\omega$, where ρ was the density of the gas at the respective height. This product vanished both at sufficiently small heights, where ω was zero, and at great heights where ρ was zero, and the rate of escape would hence have a maximum value at some intermediate level. The calculations were complicated; for helium and the earth's atmosphere (assuming the upper atmosphere to consist entirely of helium) that level would be about 600 km.

The chief point in Mr. Milne's consideration was his accentuation of the importance of the gravitational potential instead of the gravitational pull. Somebody had recently written, he remarked, that the value of gravity, at the surface of a giant star like α Orionis being only a fraction of the gravity at the surface of the moon (supposed to be unable to retain any atmosphere) all the gases should escape, and the star itself should be dissipated. The critical velocity of escape depended, however, not upon the acceleration due to gravity, but upon the gravitational potential at the respective boundary, and the surface value of that potential would be large, compared to that of the moon, even for a giant star, and might be large when g was small; for the gravitational pull fell off as the inverse first power of the distance from the centre, and not as the square of the distance.

The parameter entering into the calculations was the ratio of the gravitational molecule to the energy of the mean kinetic energy of the thermal agitation. So far as an atmosphere in purely gravitational equilibrium was concerned, the loss by dissipation should mostly be quite inappreciable.

There was a probability of escape when that ratio was low; for a given mass the ratio would, on Eddington's theory, decrease with the temperature, and for a given temperature the ratio would have a minimum value with a mass such that the radiation

pressure in the interior was one-fifth of the total pressure. Mr. Milne also pointed out that these considerations would prevent the confirmation of the Einstein displacement of stellar lines to the red, which depended upon the difference in gravitational potential between the source and the observer. In reply to Professor Whiddington he added that he had not assumed isothermal conditions, as had mostly been done; the fall of temperature in an atmosphere outward would indeed make his ρ ω maximum sharper and not less distinct.

Fifty-Four Foot Interferometer for Mount Wilson.

Professor H. H. Turner briefly described the proposed 54-ft. interferometer for Mount Wilson, mentioning that he had received a communication from Professor Hale who was unfortunately indisposed. The method, suggested by A. A. Michelson in 1890, was first tried by him in 1920 with the 40-in. reflector of the Yerkes Observatory for measuring the diameter of a Orionis. With the aid of mirrors interference fringes were produced, surrounding the image of the star, Professor Turner explained, and these mirrors were shifted and separated until the fringes disappeared. The arrangement of the mirrors was as in a range-finder; in the Yerkes instrument the mirrors could be separated to a distance of 20 ft.; in the new instrument, so far only existing in the shape of a model, the range of motion was 54 ft. The mirrors 15 in. diameter, were so mounted, both at 45 deg. (but turning from one another), on a steel girder, that the rays were deflected downward into the telescope which was not the famous 100 in. reflector, but a special telescope of 3 ft. aperture and 15 ft. focal length. The movement of the mirrors was effected by a screw, and the telescope with its attachment was provided with a hut which was run over the instruments. There was no dome, as Professor Turner explained in reply to Mr. J. Jackson. Dimensions could be estimated even if the fringes should not altogether vanish.

Double Stars.

The paper on double stars, read by Mr. J. Jackson, of Greenwich Observatory, was a contribution to statistical astronomy. Referring in particular to the information which could be derived from the study of Struve stars, he showed that it was possible in nearly all cases to separate true binary stars from mere optical combinations. Of the 2,640 pairs observed, 440 showed orbital motion, 160 were optical, and 39 doubtful, but probably optical; most of the 2,000 "fixed" pairs were apparently true binaries, and the number of optical pairs found agreed well with probability figures. For the 440 binaries, hypothetical parallaxes had been computed from mean statistical values, and we thus arrived at estimates as to absolute magnitudes and linear motions.

(To be continued.)

THE RELAY AUTOMATIC TELEPHONE SYSTEM.

(Continued from page 407.)

Fundamental Principles.—Bearing in mind the elementary principles underlying present manual practice, it is not difficult to imagine the general lines upon which a small "Relay" exchange might be designed, as it will be found that in the main, similar principles are applicable. When a subscriber on a modern manual exchange lifts the receiver he secures the services of an operator, the latter connecting an answering cord to reply to the calling signal. The number required is delivered by the caller to the operator, and the latter proceeds to establish the desired connection by means of the complementary calling cord. Finally, the operator retires from the circuit and is free to attend to other calls. Fig. 6, annexed, depicts a simple arrangement by means of which the foregoing operations may be performed through the medium of relays. To simplify the diagram, the exchange is considered as a small one serving five subscribers, whose lines terminate on separate subscribers' equipments where they enter the exchange. The principal functions of a subscriber's equipment will become apparent as this description progresses—it will suffice to indicate here the close relationship existing between manual and "Relay" practice as regards the functions of various parts.

The "Relay" apparatus that deputises for an operator is known as a recorder. An operator receives, and temporarily memorises, the number delivered by a caller, prior to seeking the called party; a recorder similarly stores or records, by means of its relays, the number dialled by a caller, and instantly selects the circuit of the called party prior to the establishment of the "through" connection. An answering cord is required to connect a caller to an operator in a manual exchange and, in a like manner, an out trunk is employed to extend the circuit of a caller to a recorder in the "Relay" exchange. The corresponding in trunk resembles a calling cord in that it conveys a call inwards to the called party after the number has been delivered. As there are two pairs of out and in trunks shown in Fig. 6, two conversations may be held simultaneously in the small exchange.

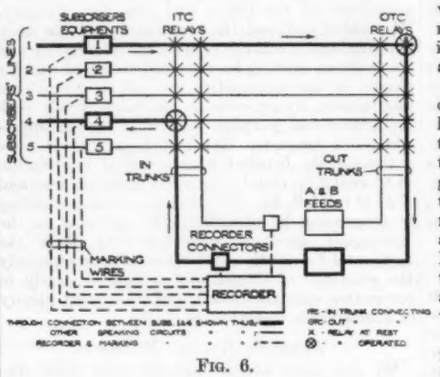


Fig. 6.

Present-day manual cord circuits provide facilities for ringing and general signalling purposes; they also contain apparatus by means of which speaking current is fed during conversation to the calling and called parties, sometimes known as the A and B subscribers respectively. The corresponding "Relay" apparatus providing these facilities has been termed an A and B feed. Switches in the form of speaking keys (these might as conveniently be termed "operator connectors") are required in manual exchanges for the purpose of switching an operator's telephone in and out of cord circuits as required. A recorder connector is similarly employed for temporarily securing the services of a recorder on an out trunk engaged by a caller.

The functions of the several essential parts having been explained, it will now be convenient briefly to trace out the progress of a call, the route of which is denoted in Fig. 6 by arrows. Let us assume that subscriber No. 1 requires to call subscriber No. 4. First the receiver is lifted, and immediately a relay in subscriber's equipment No. 1 energises, with the result that a search for an idle out trunk commences. It is assumed that the first out trunk is engaged, and that the search becomes effective on the second out trunk. The out trunk connecting (O.T.C.) relay, located at the intersecting point of line No. 1, and the second out trunk, then energises and thereby extends the caller's circuit over the aforesaid out trunk comprising an A and B feed, to the associated recorder connector. This connector thereupon energises, and engages the services of the recorder, which thereupon promptly prepares to receive the caller's impulses. At this stage, the caller is through to the recorder *via* an O.T.C. relay, out trunk, A and B feed, and recorder connector.

The foregoing cycle of operations takes effect within a fraction of a second of the lifting of the receiver. The caller proceeds to dial digit "4," and the resulting impulses pass over the line—out trunk—A and B feed—and recorder connector and thence into the recorder where they are accepted and counted. Immediately impulsing has ceased the recorder selects and energises the marking wire terminating in subscriber's equipment No. 4, which operation causes the equipment of subscriber No. 4 to seek an in trunk. This search is directed to the particular in trunk whose complementary out trunk has been already picked up by the caller, and is followed by the operation of the in trunk connecting (I.T.C.) relay located at the intersecting point of line No. 4 and the particular in trunk concerned. The two subscribers' lines are now through to each other, as indicated by the thick lines in Fig. 6. At this stage the recorder intimates to the A and B feed to apply ringing current to the in trunk and thence to the line of subscriber No. 4. Having fulfilled its function, the recorder is now released from the connection by the restoration of the recorder connector, and is then at the service of other subscribers; at the same time the marking wire of subscriber No. 4 is de-energised. When subscriber No. 4 replies, the ringing current ceases and is replaced by speaking current from the A and B feed for the duration of conversation. On conclusion of conversation, each subscriber will replace his receiver, and immediately a release cycle will take place, in the course of which all relays previously operated will return to their positions of rest. The entire connection is consequently released in an instant of time, and the in and out trunks are then available for other calls.

Trunking Scheme.—Probably no "Relay" exchange has ever been designed on quite the same lines as the one considered in the foregoing description, owing to the extravagant provision of relays that would be required in the I.T.C. and O.T.C. groups for an exchange of a size met with in practice. The limitations imposed by having only one recorder would also be serious. In their practical application the general arrangements depicted in Fig. 6 must therefore undergo certain modifications to secure an economical provision of plant and to increase the number of recorders in accord with traffic requirements.

The general trunking scheme adopted in practice for exchanges where the number of conversations held simultaneously is not likely to exceed thirty, is shown in Fig 7, on page 423. For the accommodation of larger systems further refinements are introduced to reduce the plant required to the smallest dimensions compatible with an efficient service. It will be noticed that in common with the hypothetical exchange discussed in connection with Fig. 6, the practical trunking scheme embodies subscribers' equipments—O.T.C. and I.T.C. relays, out trunks, A and B feeds, recorder connectors, in trunks and marking wires. Two recorders are shown, and this number may be increased as desired to satisfy traffic requirements. A recorder is only taken into engagement for a few seconds during the dialling period; it is not retained during conversation and, consequently, the number of recorders required is considerably less than the number of simultaneous conversations. The various functions of the foregoing circuit parts having been already alluded to in connection with Fig. 6, it will only be necessary to comment upon the extra features of Fig. 7 before proceeding with the description.

The subscriber's equipments are assembled in groups of five, every such group comprising four* connecting circuits known as links, which intervene between the subscribers' lines and the trunks. Through the medium of link connecting (L.C.) relays any subscriber's circuit in a group may be placed in communication with any one of the four corresponding links, whether for an out-going or incoming call. Every link is equipped with one O.T.C. and one I.T.C. relay, by which relays it may be switched to either an out trunk or an in trunk. The contacts of the O.T.C. and I.T.C. relays are permanently connected to the out and in trunks by means of "jumper" connecting wires, denoted by dot and dash lines in Fig. 7. These "jumpers" may be distributed over the trunks in any predetermined manner consistent with the dictates of the traffic. A trunk may be accessible to more than one group of subscribers, as exemplified in Fig. 7 by trunks 4, 5 and 6. Every link, therefore, has access to one out and one in trunk, and links up one or the other according to whether the subscriber is the caller or the called party. It will be evident

* This number may vary according to the exigencies of the traffic.

at this stage that links have a dual function to fulfil inasmuch as their services are utilised for the outgoing as well as for the incoming calls of the subscribers they serve. It is an important characteristic of the "relay" system that incoming calls to a subscriber are negotiated over the same links and equipment that are instrumental in conveying outgoing calls from that same subscriber to the exchange. This effects a substantial gain in efficiency and saving in plant on account of the increase obtained in the call carrying capacity of the circuits concerned.

It will be noticed that the out trunks are not permanently connected to the in trunks as was the case in Fig. 6; on the contrary, any out trunk can couple up with any in trunk for the duration of a conversation, through the agency of a group of relays known as the trunk-connecting group. All subscribers' equipments are connected by individual marking wires to a relay unit constituting what is known as the marker. The services of the marker may be engaged momentarily by any recorder for the purpose of reaching a required subscriber's equipment over a marking wire. Only one marker is necessary in an exchange of 1,000 lines. It is taken into engagement by a recorder immediately upon the cessation of dialling in the case of every call negotiated. The length of time it is thus engaged never exceeds a small fraction of a second, and this period is entirely independent of any action on the subscriber's part.

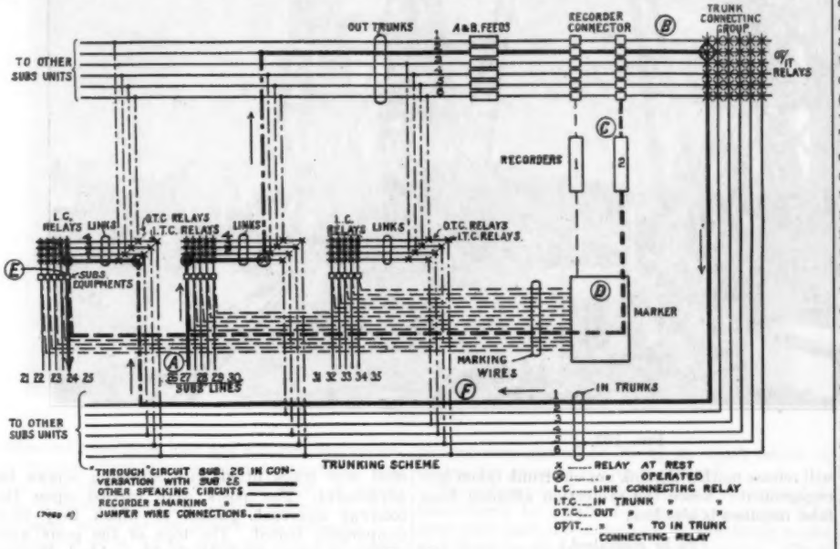


FIG. 7.

Progress of a Call.—The route of a call originated by subscriber "26" for subscriber "25" is depicted in Fig. 7 by means of thick lines, the sequence of operations being represented by alphabetical lettering. The operations may be divided into four distinct stages, thus: (1) Predialling, (2) dialling, (3) marking, (4) conversation. The pre-dialling stage commences the moment a caller lifts the receiver, and materialises in a minute space of time in the following manner: Immediately upon lifting the receiver subscriber "26" energises the line relay located in his equipment in the exchange. The operation of this relay institutes a search for an idle circuit over the four links in the group and their associated out trunks. It is assumed in Fig. 7 that link No. 1 and its associated out trunk No. 2 are idle, consequently the search is arrested at the first link. This link and its out trunk are promptly taken into engagement by the operation of the corresponding L.C. and O.T.C. relays, thereby extending the caller's line to the A and B feed belonging to out trunk "2." Simultaneously with the establishment of this connection the link and out trunk are made to test engaged to other callers by the operated O.T.C. relay combined with the energisation of a guarding relay (G.) in the A and B feed. The progress of the call at this stage is denoted in the figure by the thick line from A to B.

Both an A and B feed and a recorder connector are permanently incorporated in every out trunk. The operation of the guarding relay in the feed not only causes the out trunk to test engaged, but intimates to the associated recorder connector that the services of a recorder are required. The recorder connector instantly seeks an idle recorder and, having found it, initiates a cycle of operations therein which prepares the recorder for the reception of impulses. It is assumed in Fig. 7 that recorder "1" is already engaged and that recorder "2" is idle. By ingenious circuit design the recorder, although prepared at this stage, is not definitely engaged with the out trunk (via the recorder connector) until the arrival of the first impulse from the caller's dial. Until then, the recorder is not made to test engaged, and may be appropriated for a more pressing call should subscriber "26" fail to dial. This is a valuable feature, as it prevents a recorder being held up by a dilatory caller at a time when, all other recorders being engaged, no recorder is available to negotiate a call from another subscriber who is prepared to dial immediately. It also precludes the possibility of the exchange being deprived of the services of a recorder should a subscriber's line develop a fault resulting in the temporary engagement of an out trunk. Should a caller be deprived of a particular recorder owing to an unreasonable delay before dialling he would be switched to the first recorder to become idle in its stead.

The foregoing operations, constituting the pre-dialling stage, all take effect in a moment of time after the receiver is lifted, with the result that a recorder is prepared and waiting well before dialling commences. The dialling stage is entered upon when the caller commences to dial. Assuming the first digit to be "2" the dial will be rotated accordingly and, in the course of its return travel two impulses will be sent to the exchange. The first impulse causes recorder "2" to be definitely taken into engagement with subscriber "26" and no other caller can then secure its services. Therefore, after the arrival of the first impulse the entire circuit from the caller to recorder "2" (A to C in Fig. 7) is safeguarded against interference. The counting operations in the recorder, which synchronise with the caller's impulses, are regulated by a train of "counting" relays. Two of these relays respond to every impulse, one at the commencement of the impulse, the other at the end. The two impulses from the caller's dial in the call under review progress through the "counting" relays and, during the pause that ensues while the caller is rotating the dial to the second digit "5," the "counting" relays transfer the first digit "2" to a particular "storing" relay which operates and locks up for the purpose. Having performed this service the "counting" relays reset in readiness to respond to the second train of impulses about to arrive. The second digit is dealt with in a similar manner and the recorder is then set for number "25."

The marking stage now matures. The recorder secures the services of the marker, through the medium of which it energises the marking wire terminating in the equipment of subscriber "25." This circuit is indicated in Fig. 7 by the thick broken line C—D—E. Should the marker be engaged elsewhere the call is not lost, but operations are merely suspended momentarily until the marker becomes available. The marking operation results in a search for an idle circuit being originated by the equipment of subscriber "25." This search is directed over the links in the group and their associated in trunks, the out trunks being suppressed on this occasion as the call is an inward one. Let it be assumed that the search is effective on link "1" and in trunk "1," and that consequently both these connecting circuits are taken into engagement by the operation of the corresponding L.C. and I.T.C. relays, specially identified in the figure. The circuit of subscriber "25" is thereby extended over the link and in trunk to the trunk connecting group of relays, and at the same time the said link and in trunk are made to test engaged. Simultaneously with the foregoing search the recorder connects an identifying polarity to all six O.T./I.T. (out trunk to in trunk) connecting relays associated with out trunk "2" in the trunk-connecting group. These relays are shown in the figure in alignment with out trunk "2." Only one of these relays is located at the intersecting point of out trunk "2" and in trunk "1," and in consequence of this it is the only relay that is energised in the trunk-connecting group in connection with the call in question. The operation of this relay establishes the desired connection between out trunk "2" and in trunk "1." Prior to detaching itself from the connection the recorder energises a ringing relay in the A and B feed, with the result that the ringing apparatus in the exchange is set in motion and ringing current is sent out from the A and B feed to subscriber "25" over the circuit denoted by B—F—E.

The marking stage having materialised, both the recorder and marker are released and become available for negotiating other calls: neither of them is held during conversation. Immediately subscriber "25" replies the ringing relay is tripped, and is replaced by a current feeding relay "B" in the A and B feed. As there is a corresponding current feeding relay "A" at the caller's end of the A and B feed, both subscribers are now fed with current for speaking purposes. The "through" circuit (A—B—F—E) having been established and protected from the possibility of interference on the part of other subscribers, the entire connection is complete and conversation may proceed. The time occupied from the moment that a caller commences to dial until the bell of the called party is rung is determined only by the speed with which the caller dials the number required. In the case of a two digit number this would average about 2 seconds.

Release.—The release of the connection on the conclusion of conversation may be so arranged that either subscriber can clear instantly by replacing the receiver. It is more usual, however, for the control of the instantaneous release to be vested in the caller only. Under such circumstances a delayed back release is provided in the interests of the called party, so that should the caller alone omit to replace the receiver either through negligence or with intent, the entire connection would be released at the end of one minute, or other predetermined period, through the medium of a thermostatic device. The offending subscriber's line would thereafter be prevented from attempting to originate a new call in the course of which it would recommence the usual cycle of operations to pick up an out trunk and recorder; on the contrary, the line would be held up in its own equipment and attention would be directed to the irregularity by an alarm. The restoration of the caller's receiver, however, would remove all restrictions immediately. Both the instantaneous and the delayed release take effect by de-energising the guarding relay (already mentioned) in the A and B feed. Immediately this relay falls away all holding circuits in the connection are opened and all relays concerned return to their positions of rest. The guarding relay that controls the release is purposely made sluggish in its action, so that should a

THE ERECTION OF THE RIACHUELO TRANSPORTER BRIDGE.

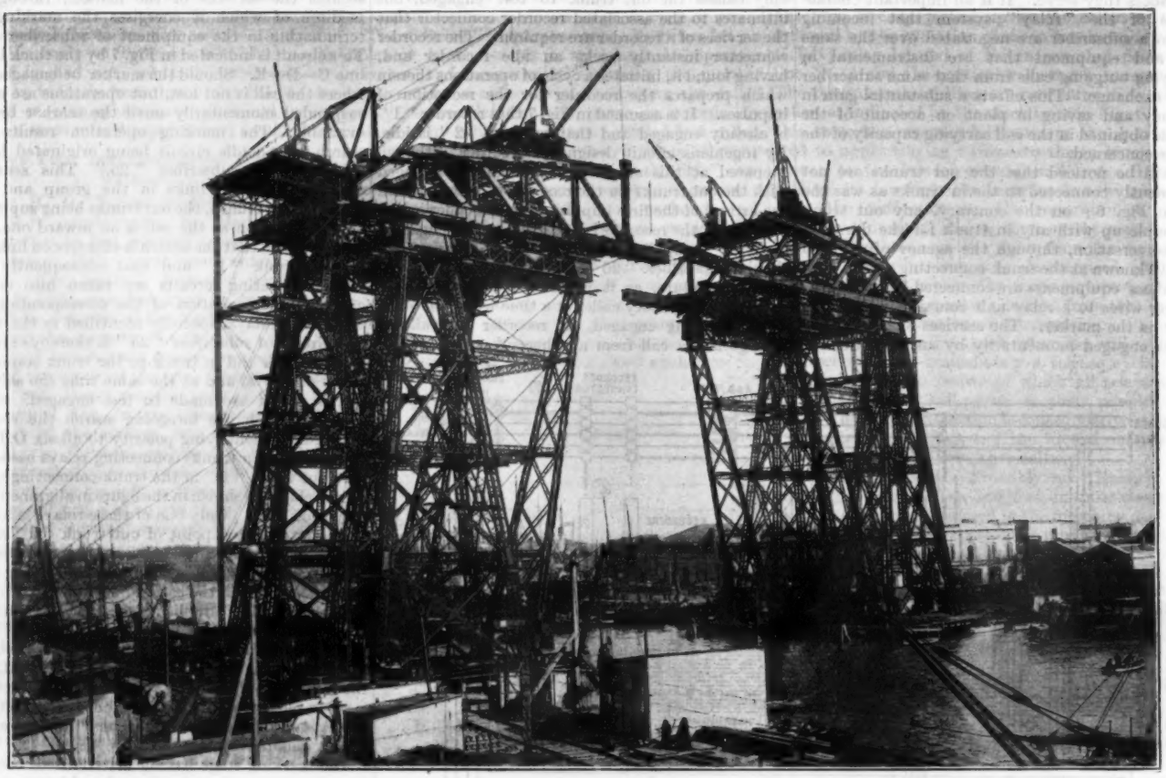


Fig. 133.

subscriber accidently knock the switch hook during conversation the connection would not be severed.

Abnormal Conditions.—If a called party be engaged at a time when a caller dials his number, the marking wire remains inoperative at the marking stage, and the recorder being unable to perform the necessary marking operation, intimates the fact to the A and B feed. This results in the operation of a busy back relay in the feed, which in turn applies an audible engaged tone to the caller's circuit as an indication that the call can not mature. Once the busy back circuit has been established in the A and B feed the recorder, having no further operation to perform, is released and is then at the service of other callers.

If a subscriber remove the receiver and then fail to dial a number the operations that accompany the pre-dialling stage of an originated call ensue as usual. In such a case a link and out trunk is taken into engagement, and a recorder is prepared. At the end of one minute, however, the operation of the thermostat in the A and B feed forcibly releases the link, out trunk and recorder, and holds up the offending line on its own equipment until such time as the receiver is replaced; in the meantime an alarm is given. Should a fault develop on a subscriber's line and cause the engagement of a link and out trunk, or should a subscriber dial part of a number and then leave the telephone without replacing the receiver a release cycle similar to the foregoing results.

The circuits are so designed that should a caller wish to abandon a call at any time, either before or in the middle of dialling, everything is instantly and effectively released when the receiver is replaced. The mutilation of a call owing to a caller inadvertently knocking the switch hook prior to dialling is guarded against. The accidental impulse that may be transmitted to the exchange under these circumstances is rejected by the recorder, which thereupon resets and nothing prejudicial to the eventual establishment of the desired connection results. The momentary break in the line circuit will release neither the link nor out trunk taken into engagement; hence the protection afforded from false impulses is absolute.

(To be continued.)

RIACHUELO TRANSPORTER BRIDGE, BUENOS AIRES.

By P. J. Ridson.

(Concluded from page 356.)

Erection.

Temporary Erection.—Before shipment, portions of the work were temporarily assembled at the maker's works. Each set of four tower legs and bracing were laid out on the ground and bolted together (see Fig. 22, page 195 *ante*), the suspension frame was similarly dealt with, and the superstructure was erected complete (Fig. 50, page 238 *ante*). The trolley framing was bolted together and mounted upon its bogies on a temporary track, and it was found that 20 men could start it from rest and keep it moving. The machinery was assembled and tested as a complete unit and the electrical equipment was also tested separately.

Erection at Site.—After completion and testing of the masonry piers, the tower bases were placed in position by means of a floating crane, and concreted round to a height of about 6 ft., the concrete being sloped to drain off rain water. The tie girders between tower bases were also encased in reinforced concrete. The bottom lengths of tower legs and the first tiers of tower bracing were then erected by means of ordinary steam travelling cranes. On each of the eight shore piers a load of 20 tons of rails were placed, before erection of the superstructure was commenced.

At this stage, a light steel stallage was run up at each tower, each stallage consisting of four vertical steel, lattice box posts, each composed of four 3½-in. by 3½-in. by ⅜-in. angles and single lacing bars, and connected by horizontal lattice struts, and diagonal bracing consisting of ⅞ in. diameter steel wire ropes fitted with straining screws for adjustment. The posts were carried upon the roadway approach girders to which they were temporarily bolted. The tops of the posts were connected transversely by double webbed, Warren girders, 3 ft. 7½ in. deep with cantilever ends, and longitudinally by single-webbed Warren girders. These girders carried light, subsidiary lattice girders, and, with the latter, formed a support for two erecting cranes described later. The height of the stallages, which may be seen in Fig. 132, page 425, from top of masonry piers to top of girders, was 147 ft. 4⅞ in. The stallages were guyed by steel wire ropes to the outer tower bases, and decked with timber to form a working platform.

A 2-ton hand derrick crane of 35 ft. radius was mounted on top of the stallage, by means of which the parts of the 5-ton electric erecting cranes were lifted and assembled. This 2-ton crane was worked by means of a hand winch at ground level.

On each of the stallages a 5-ton electrically-driven derrick crane was mounted, provided with two jibs of 50 ft. radius, so placed as to enable them to pick up and place in position the tower steelwork, thus completing the towers from the level of the first tier of bracing to the top, after which the cranes were used for erecting the temporary steel cantilever booms and bracing. Finally the same cranes served to erect such portions of the superstructure as lay within their radius. The crane jibs, masts and back stays were of built-up steel sections, with slewing tables toothed all round to enable them to be revolved in a complete circle in either direction, by altering the positions of the backstays. They were designed to clear all fixed portions of the bridge. The height of lift was 170 ft. Motors and solenoid and hand brakes were included.

To the bases of the four outer legs of each tower, built up, steel brackets were temporarily bolted. Each of these brackets supported a pin bearing comprising a cast-iron bearing with an 8 in. diameter steel hinge pin. The bottom ends of the raking booms were heavily reinforced by thick gusset

ERECTION OF THE RIACHUELO TRANSPORTER BRIDGE.

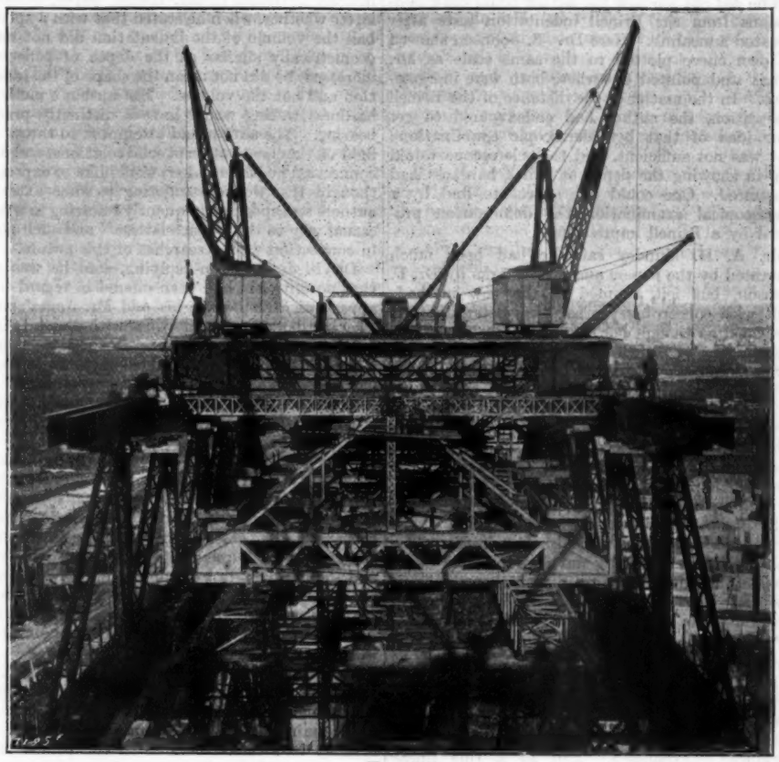


Fig. 134.

plates and rolled steel joist and channel diaphragms, the bottom edges being machined grooved to bear upon the pins. There were two pairs of booms to each tower, Fig. 132, projecting upwards to about the same height as the towers and outwards to a distance of 64 ft. 11 in. from the centre of tower. Each boom was 125 ft. 4⅜ in. long, centre to centre, of pins and was of box section, consisting of a pair of tapered web plates and four 5-in. by 4-in. angles, all of varying thickness, with single angle lacing bars. The booms of each pair were inclined, the spacing at the base pins being 22 ft. 11⅛ in. and 5 ft. 3⅛in. at the top pins where they supported the outer ends of horizontal tie girders to which they were secured by 8 in. diameter steel pins. At intermediate points the booms were connected to the corresponding tower legs by horizontal lattice members which were inserted as the booms were built up. The booms were braced in pairs by diagonal members consisting of 6-in. by 2½-in. rolled steel channels, and pairs of 12-in. by 3½-in. transverse rolled steel channels. Horizontal lattice box members connected the two pairs of booms and the panels thus formed were braced by 1¼ in. diameter steel wire ropes fitted with tension blocks and screws for taking up stretch in the ropes.

From the top of each half of the tower a pair of box girders spanned the intervening distance to the upper ends of the raking booms. These girders served as ties to the booms, thus completing the cantilevers, and also as supports for the main girders during erection. Each girder was 6 ft. deep with vertical N web bracing consisting of 9-in by 3-in. rolled steel channels. The flanges comprised pairs of 5 in. by 4-in. by ½-in. angles and 18-in. flange plates. The two girders were spaced 4 ft. 10¼ in. apart centre to centre, and were braced together horizontally by double diagonal flat bars and transverse angles. At one end they were riveted to gusset plates projecting from the towers and at the other end were connected to the raking booms by 8-in diameter steel pins. At two intermediate points the vertical web bracing was reinforced by ½-in. vertical web plates, where the weight of the main girders was borne. The two pairs of girders were spaced 55 ft. 9½ in. apart centre to centre (the same as the main girders).

The outer ends of erection girders were connected, transversely by a pair of Warren type girders 6 ft. deep with pairs of 3-in. by 3-in. by ⅜-in. flange angles and 3½-in. by 2½-in. by ⅜-in. web bracing. These two girders were spaced 6 ft. 6 in. apart centre to centre, and braced together horizontally by double diagonal lattice bars and transverse angles. At intermediate points, three other transverse girders of a similar design spanned between the two main longitudinal erection girders. Two intermediate longitudinal girders, of the same depth and section, were provided between the transverse tower girder and the jib girder. Although the various intermediate girders were required for the support of portions of the superstructure during erection, they were subsidiary to the tie girders between the towers and booms, which carried the greater part of the load.

Timber packings were laid upon the erection girders so as to give a slight upward inclination to the main girders as they were built out from the bearings which were first fixed in position. The end lengths of the bottom booms were then hoisted, and laid out and erection proceeded in the usual manner, as far out as the stallage cranes could deal with it; from the end of the girders to their supports over the tops of the erection booms, all the cross bracing, cross girders and bracings were riveted up.

When erection had proceeded as far as the radius of the stallage cranes permitted, steel framed travelling stages were mounted on wheels running upon rails laid on top of the completed portions of the main girders. One of these travelling stages was provided for each half of the bridge. A good view of one of these travelling stages is given in Fig. 133. Each stage was 20 ft. long centre to centre of side framing girders and 55 ft. 9½ in. wide centre to centre of wheels, and comprised a pair of main transverse girders connected by five longitudinal girders and with an intermediate transverse tie girder. Each end of each of the main transverse girders was carried upon a four-wheel bogie (four bogies in all). The forward bogies were arranged at a higher level than those in the rear so as to conform to the incline of that portion of the curved main girder booms along which the staging had to travel, and so maintain an approximately level deck for the crane supports. The transverse girders of the staging were 5 ft. 6 in. deep and all the girders were of *N* or lattice type as shown. The bogie centres were pivoted upon 3-in. diameter pins passing through pin plates projecting downwards from each end of the two main transverse girders. The bogie carriage consisted of a pair of 9-in. by 3½-in. rolled steel channels, to the undersides of which the bronze-bushed cast-iron pedestals were bolted. The wheels were of cast steel, flanged and 11⅛ in. diameter on tread.

On each of these travelling stages two 5-ton electric derrick cranes of 35 ft. radius were mounted in such positions as enabled them to pick up materials from the stallage platforms and runways and place them in position ready for riveting up. Temporary timber runways were erected, one over each pair of track girders, extending from the ends of the girders to the fourth main girder vertical member. Four of these runways in all were provided, and temporary bogie trucks were mounted upon them for transferring the bridge material from the stallages to within reach of the travelling erecting cranes. Netting was provided beneath the superstructure during erection to obviate the danger of falling tools, rivets, &c., and as a protection to the workmen.

As erection proceeded the travelling stages were hauled up the incline of the main girder top booms by passing the burden ropes of the cranes through a snatch block fitted to the front of the platform and anchoring it to a projecting portion of the permanent structure.

By means of the travelling derrick cranes the main girders were built out, cantilever wise, beyond the temporary boom supports, to the middle of the span. The final adjustment of the projecting ends was effected by inserting hydraulic jacks between the bottom booms and the erection girder and lowering the main girders until the ends were in alignment, when the ends were temporarily coupled with bolts and finally riveted up. Eight 100-ton hydraulic jacks were employed for this purpose. When the projecting ends of the main girders had been riveted together, the remainder of the bracing, cross-girders, track girders, &c., were riveted up and the superstructure was completed.

The overhead trolley framing was assembled on the bogie trucks at one end of the main superstructure girders, and the suspension frame was built downwards from the trolley pin connections. Meantime the transporter car was erected upon staging, at its correct level, at the other end of the bridge. The trolley was then hauled across and attached to the car by the four 3¼ in. diameter suspension links.

After the removal of the cranes, stallages and temporary steelwork, the engine-house was erected, and the machinery and electrical equipment installed. The dismantling of the temporary steelwork presented no difficulty or feature of special interest, being carried out in reverse order to its erection.

The construction of the bridge occupied three years from commencement to completion, including the time taken in dismantling the cranes and temporary steelwork, a considerable portion of this time being due to delays in the shipment of materials. The plant employed was of a comprehensive description and was in duplicate, one complete set being provided for each half of the bridge, including an electrically-driven air compressor and a complete pneumatic drilling and riveting outfit. The bridge was opened for traffic in June, 1914.

Messrs. Livesey, Son and Henderson, of London, were the consulting engineers for the bridge, which was manufactured by the Patent Shaft and Axletree Company at their Old Park Ironworks, Wednesbury. The electrical equipment was supplied by the General Electric Company. The bridge was erected under the administration of the railway company. The writer of the present article is indebted to the Secretary of the Buenos Ayres Great Southern Railway, and to Messrs. Livesey, Son and Henderson for permission to publish details of the bridge and for the photographs and drawings reproduced.

THE INSTITUTE OF METALS.

(*Concluded from page* 396.)

Linear Shrinkage of Cast Metals and Bottom-Pouring.

At the meeting of the Institute of Metals on the morning of Friday, the 22nd ult., in Llewellyn Hall, Y.M.C.A., Swansea, the first paper taken was entitled "New Forms of Apparatus for Determining the Linear Shrinkage and the Bottom-Pouring of Cast Metals and Alloys, with Data on the Shrinkage and Hardness of Copper-Zinc Alloys," by Dr. F. Johnson and Mr. W. Grantley Jones. It was read in abstract by the former.

The paper described two new apparatus, for determining the total linear shrinkage of cast metals and alloys, and for producing cast bars by a bottom-pouring method, the molten metal flowing from a specially heated crucible into the mould, the rate of flow being controlled by a lever-operated stopper. The shrinkage values of these alloys were found to be higher in general than those obtained for sand-cast bars by previous investigators. In regard to hardness, the Brinell curve showed an increase of hardness over the range 100 per cent. to 88 per cent. of copper; from 88 per cent. to 72 per cent. of copper the hardness was constant, a slight falling setting in at about 72 per cent. and persisting to 63 per cent., at which point a rapid increase set in with the appearance of the beta constituent. With the exception of a small dip in the curve between 53 per cent. and 50 per cent. of copper, the increase was maintained to 45 per cent. of copper. The changes of scleroscope hardness with composition were of a similar character to those revealed by the Brinell test, but less pronounced, whilst over the range 60 per cent. to 53 per cent. of copper, no increase of hardness was shown such as shown by the Brinell test. This would indicate a very slight difference, scleroscopically between the beta and alpha phases.

The Hardness of the Brasses.

This paper was taken for discussion together with the one on "The Hardness of Brasses, with some Experiments on its Measurement by means of a Strainless Indentation." It was by Mr. F. W. Harris, who read it in abstract.

In this, the author stated that the theories generally advanced with regard to the connection between hardness and internal constitution had been in the main substantiated. There were, however, certain anomalies which could only be explained by adopting a modified idea of the existing constitutional diagram. A slight maximum was shown in the middle of the alpha phase, and a small depression in the beta phase. The author referred to the "strain-hardness produced by the ball," and illustrated the indentation as first made and after annealing the specimen, pointing out the marked improvement in the shape of the indentation.

The discussion on the latter paper was opened by Dr. F. Johnson, who found that the author had approached the subject in a clear and systematic way. Mr. Harris' Brinell hardness curves appeared to show that there was a maximum hardness between 100 per cent. and 70 per cent. of copper. Murray had referred to the proportion of 79 per cent.; his (the speaker's) attitude was that one should not be obsessed with the Meneghini-Turner-Murray law concerning the maximum in the alpha phase, since although he did not at all dispute the possibility of a maximum at that point, he could not say he had found it. For all practical purposes under the most favourable conditions dealing with alloys in shop work one could not expect to find a maximum in the curve. Dr. Johnson and Mr. Jones were on common ground wih the author only in the chill cast and annealed specimens. The locations in the maxima of the author's curves were not in agreement. They were elusive maxima, and he did not think that sand-cast bars were quite reliable for supporting the assertion of the said maxima. Even as annealed, it might be said that sufficiently constant conditions had not yet been obtained to justify any dogmatic assertion concerning any particular maximum in the series under consideration. With reference to the author's strainless indentation test, he thought there might be a little flaw in this, connected with the grain size; there were two metals alloyed, one harder than the other, deforming differently. If annealed the difference remained, and he did not see how the author could draw conclusions from the Brinell indentation tests after repeated annealing. Here Dr. F. Johnson showed his own curve plotted to the same scale as Mr. Harris' and pointed out where both were in agreement. In the matter of the distance of the Brinell penetration, the author had endeavoured to get some idea of that by microscopic examination; that was not sufficient, and the scleroscope would help in showing the depth at which hardness had penetrated. One could not expect to find by a microscopical examination the deformation produced by a Brinell impression.

Mr. A. H. Mundey said he had been much interested by the papers and the remarks by Dr. F. Johnson, but felt alarmed at the new methods dealt with concerning the hardness determination. It seemed as though one's faith was being broken in the matter of Brinell hardness tests. During the war he (the speaker) had experienced trouble in what he would design as the "cutability" of metals; work was required to be delivered rapidly and metals were gradually becoming too hard to cut quickly. This led to trouble with the men from the point of view of output, the metal being harder than that upon which the labour price rate was established. He thereupon introduced the Brinell hardness test, with corresponding increase, or decrease in rate with the hardness, and this worked satisfactorily. The fresh standards now being put forward were likely to shake the faith of engineers, just when the hardness test was establishing itself. He hoped all cause for alarm in the matter would be removed.

Professor Turner welcomed both papers, which introduced many points that could be discussed at great length. The first one dealt with a new form of apparatus for determining linear shrinkage, and he congratulated the authors on the use of that term. He (the speaker) with former researches had introduced "expansion," and as a rule linear increase and decrease corresponded with volume changes. He was interested to see that the work of the authors of the first paper showed close correspondence with the work done by Meneghini, Turner and Murray. Dr. Johnson had said that his own curve of his and Mr. Jones' results (Fig. 5) showed little difference from that of Murray, but that the values were greater in all cases than those obtained by Murray; in this connection it should be noted that the authors had a much larger number of observations than was the case in the earlier observations. It should be noted, further, that one was apt to draw a curve giving more attention to the point than deserved, as Murray did. He was pleased at the two sets of hardness tests made by independent observers; the general agreement was good. In Messrs. Johnson and Jones' hardness curves, a small part of these, at about 80 per cent. of copper—where there was a straight line—a curved line might possibly be drawn. In regard to Mr. Mundey's remarks as to the Brinell hardness test, this remained useful from the engineers' point of view, but it was an indifferent one from that of the scientists. There occurred deformation and surface hardening in many cases, and Mr. Harris had attempted to get over that difficulty.

Dr. Rosenhain, dealing particularly with the Brinell test, said it was interesting to find that Mr. Harris had done something useful towards the knowledge of hardness, but he had not touched bottom, and had to reckon with the getting of strained grain, grain growth and recrystallisation. He had not reached the elastic limit of surface deformation. In reply to Mr. Mundey he (the speaker) would say that when a faith really existed it was not easily shaken. The Brinell test was a useful one, and it was easy to correlate the tensile stress with the Brinell number. But, notwithstanding, the Brinell test was being pushed too far. In regard to the maximum in the Brinell hardness curve, this was rather a discussion on academic lines, since these alloys were not in a complete state of equilibrium, and it was not to be expected that complete agreement would exist between the various workers. In experiments of the kind dealt with it was impossible to get complete correlation in theoretical curves.

Professor C. A. Edwards, after expressing the interest he found in Mr. Harris' paper, asked the latter whether, when he stated that with a spherical ball the volume of the indentation did not remain geometrically similar as the depth of penetration increased, he did not mean the shape of the indentation and not the volume. The author's method of hardness testing would have a distinctly practical bearing. The author had attempted to throw some light on the constitution of solid solutions, and in this connection he (the speaker) would like to express the thought that we were suffering to some extent by authors and speakers frequently referring in a rather casual way to the "space lattice" and such points, in connection with researches of this nature.

Dr. F. Johnson, in replying, said he was sorry that no criticism had been offered in regard to the apparatus described in his and Mr. Jones' paper; they had hoped for suggestions with a view to modifications and improvements. In the matter of the Brinell hardness test, he added that his faith in it had been shaken as a test for "workability." He thanked Professor Turner for his remarks, but did not agree with him on one point, for the work done by Meneghini was carried out under entirely dissimilar conditions, and no comparison could be drawn between his, the Johnson and Jones, and the Harris results. When Dr. Rosenhain spoke of the relation between the Brinell and tensile tests he, perhaps, had steel in his mind, for he (the speaker) had not found a relation between the tensile test and the hardness test of copper. Mr. W. G. Jones, the co-author of the former paper also regretted that the apparatus had not been commented upon in the discussion, and expressed the hope that this would be adopted at a future date.

Mr. F. W. Harris, in the course of his reply, said that each of his points had been arrived at by six determinations, and he had tried to draw his curves in as unimaginative a manner as possible. Mr. Mundey had been answered in the course of the discussion. If the Brinell hardness figure is not so satisfactory as one could wish, any effort to investigate the test more deeply is justified. With regard to the differential rate of grain growth round the area of the impression when annealed, he did not find that crystal growth had affected the hardness to any considerable extent and doubted whether it would have any great bearing upon the hardness figure obtained.

The Structure of Eutectics.

The third paper taken on Friday, 22nd inst., had the above title, and was contributed by Mr. F. L. Brady, who read it in abstract.

It dealt with the structures exhibited by eutectics, mainly those between metals and metallic compounds. The eutectics examined fell distinctly into three classes, for which the terms "globular," "lamellar" and "angular" were suggested as convenient terms. The structures agreed well with what would be expected from theoretical considerations of the effects of surface tension and cohesion.

The discussion was opened by Mr. A. H. Mundey, who said his firm manufactured printing metals and made an alloy for linotype machines which remained molten for a long time; also, and with great success, antimony lead alloys for acid-resisting materials which latter alloys were obtained of a fine grain by rapid cooling, and were less liable to pitting and to attack than if cooled slowly. He asked whether the author could explain these points.

Professor Turner complimented the author upon his work; the present paper was his first one and it showed considerable promise. He then pointed out the various ways in which a material could solidify.

Dr. F. Johnson found that the paper opened up an interesting field of observation; he disagreed somewhat with the author's differentiation in the solidification phenomena of metallic and non-metallic bodies, and asked him to clear up the points.

Dr. O. F. Hudson congratulated the author on his most excellent microscopical work. He thought surface tension must play an important part in the

phenomena dealt with. In regard to the author's classification of the eutectics into three classes, he (the speaker) suggested that the "lamellar" class was perhaps the fundamental one. He had been interested with the eutectic of copper and copper phosphide, and this was affected by a small amount of impurities; so far as he had gone he had concluded that the impurities tended to break up the eutectic, which assumed a coarser form. The coarsening of the eutectic at the boundaries might thus be connected with the impurities.

Professor C. A. Edwards expressed his appreciation of the very able way in which the author had carried out his experimental work, and on the admirable manner in which he had handled the theoretical side of the subject. He asked, mainly with the object of drawing the author's attention to a side of the problem that he had in mind but which he had not dealt with, when considering the relative sizes of the two constituents in a binary eutectic at the centre of the grain and at the outside of the grain, and the quantity of those two constituents, was it safe to assume that there was any more of one of those constituents at the boundaries of the grain in actual fact, or was it an optical effect due to the coarsening up of the structure? He knew it was difficult to attempt to determine the relative volumes of the two constituents in the centre and the outside, but it might be useful if some actual data could be obtained so that it would be possible to get away from the personal factor when examining it in a visual manner. That might throw more light on the problem. He also desired to ask if the author thought that the coarsening up that was obtained on passing from the centre to the outside was probably due to the fact that the constituents must necessarily have had a little longer time to coalesce during their solidification.

Mr. F. L. Brady, in reply, after thanking the speakers for the very kind way in which they had received his paper, said the solution to Mr. Mundey's difficulty would, he thought, be found in complete consideration and examination of the ternary diagram of the system he had mentioned, namely, that attention be given to the more complete clearing up of some of the difficulties which still remained in the diagram. Mr. Mundey really wanted for his purpose something comparable with the work which Dr. Rosenhain and Mr. Tucker did on the alloys of lead and tin. With regard to antimony-lead eutectic, he thought the fact that probably less pitting took place with a fairly rapidly cooled material was due to the fineness of grain of the material although he would not like to be considered as expressing a dogmatic opinion on that point. He thanked Professor Turner for his kind remarks. In reply to Dr. Johnson, so many factors came into play in connection with coalescence besides that of surface tension, and there was such a fundamental difference in the nature of copper and copper oxide that before a conclusion could be reached on that point, other questions would have to be taken into consideration. He could not see any reason for altering the word "between" in the description of the eutectic between silica and felspar. The eutectic would certainly be composed of the two bodies, and on an equilibrium diagram the proposition would be found between the two. There were, however, two senses in which the word might be used. Dr. Hudson's words of encouragement on the micrographs were greatly appreciated. He (the speaker) quite realised that the difference between the "lamellar" eutectic and the "globular" eutectic was one of degree and not of kind. There was no hard and fast line of demarcation. He put forward those two divisions as being a convenient method of dividing them up. Both Professor Edwards and Dr. Hudson had alluded to the coarsening at the boundaries of the eutectic. He had hoped that Dr. Rosenhain would have had a word to say on that subject because Dr. Rosenhain and Mr. Tucker were, he believed, the first to draw attention to it. But the conclusions which could be drawn from the micrographs were not by any means certain, and he would prefer not to attempt to reply on that point.

The Antimony-Bismuth System.

The fourth paper taken dealt with the above subject. It was by Mr. M. Cook, in whose absence it was taken as read.

It stated that thorough thermal and microscopic examinations had been made, and the results obtained, in addition to those from quenching and annealing experiments, showed that the two metals formed an isomorphous series of alloys. Twin crystals and peculiar banded effects had been observed in some of the annealed specimens. The nature of the bands had not been definitely ascertained, though they were not considered to be slip bands.

Miss M. L. V. Gayler exhibited a diagram of hers showing the similarity of her results with those of the author. She asked for the rate of cooling in several instances where the author had stated that the specimens had been slowly cooled, and for the rate of cooling generally.

Dr. J. L. Haughton said that with reference to the author's remarks on difficulties with his solidus curves, he would have been better advised to use the inverse rate method. In his annealing experiments he asked the author in what way he controlled his temperature and maintained this steady during the long periods at which he worked, also his reasons for selecting a thermo-couple of niohrome-constantan. An iron-constantan couple would have been an advantage.

Other speakers on the paper were Mr. U. R. Evans and Professor C. A. Edwards who raised points relating to certain micro-photographs reproduced in Mr. Cook's communication. These criticisms, however, would be unintelligible in the absence of the illustrations and we, therefore, do not report them. In the absence of the author there was, of course, no reply to the comments made in the discussion.

Red Stains on Silver-plated Work.

The fifth paper, contributed by Mr. A. Jefferson, was entitled "The Cause of Red Stains on Silver-plated Work"; it gave particulars of the tests carried out, and stated that the red stains were caused by the indiscriminate use of rouge in the finishing and polishing processes, through the absorption of rouge into the open pores of the surface, this being heated by the friction of the hand or finishing dolly.

The paper was introduced by Dr. R. S. Hutton, and Professor Turner said that the decision given in the paper was no doubt the right decision, namely, to refrain from applying rouge to an over-heated surface, and go to a fresh part of the surface, then returning to the cooled original part of the surface.

Intermetallic Actions.

The last paper dealt with, "Intermetallic Actions: The System Thallium-Arsenic," by Mr. Q. A. Mansuri, in whose absence it was taken as read.

Miss Gayler criticised the author's conclusion to the effect that thallium and arsenic did not form any solid solutions, saying there was not sufficient evidence in the paper to justify that conclusion; also his conclusion as to the equilibrium diagram of the system.

All the authors received the thanks of the members for their contributions.

The usual vote of thanks to the Mayor, to the Y.M.C.A. for the loan of their premises, and to the Hon. Local Secretary, Mr. Lewis Jones, terminated the meetings.

Swansea Local Section.

It was then announced that steps were being taken for the formation of a local section of the Institute of Metals in Swansea.

Strength of Concrete Stoppings in Coal Mines.—For the purpose of determining specifications for the construction of concrete stoppings in coal mines that may be developed on the public lands of the United States, the Bureau of Mines, in co-operation with the Bureau of Standards, is constructing in the experimental mine at Bruceton, Pa., a chamber in which it is proposed to conduct tests to determine the strength of reinforced concrete stoppings when subjected to a pressure, up to 50 lb. per square inch, suddenly applied. The tests require the construction of a permanent stopping, which was completed at the close of the fiscal year, and a test stopping, which is under construction in accordance with a design prepared by the Bureau of Standards.

TEXTILE MACHINERY AND ACCESSORIES EXHIBITION AT MANCHESTER.

The textile industry in this country is in the same position as most of the other main industries. The condition is one of great depression. There are few inquiries regarding possible business, and very few orders. The rate of exchange, the general state of unrest pervading the whole world, and the additional trouble in the Near East, all contribute in part to this state of affairs in the textile world. There is but one field where there seems to be some activity, and that is in textile machinery. This activity is concentrated on buying machinery for export. It is under such conditions that the exhibition at Manchester of plant and accessories for cotton mills will be opened to-day (Friday) by Sir Edward Mackay Edgar.

The City Hall is filled with exhibits showing the trend of development in textile machinery. The floor space is by no means large, but it is gratifying to know that more space would have been utilised had it been available. Although many representative cotton machinery firms in this country are not exhibiting at all, what is shown by the firms who have been successful in obtaining space is both instructive and interesting. The trend of development in machinery of this class seems to be solely confined to the refinement of detail, and not to any revolutionary change. As exhibits of Swiss, French and American plant are shown beside those of British firms, it is possible to compare the outlook in all the main centres of manufacture. The development by simple step-by-step progression seems to be characteristic of the industry in all lands.

The exhibition was organised by the proprietors of *The Textile Recorder*, who ran similar ventures in 1911 and 1914. Mr. Frank Nasmith, the Editor of that journal, is to be congratulated on the success of his work in bringing together such an exhibition. The Committee have always had before them the interests of such institutions as Overlookers' Societies and arranged for visits by these organisations on various dates throughout the run of the show. The competition in textile designs seems to have raised a great deal of interest in places far remote from the textile works, and, as a matter of fact, the best of the designs received were sent in by art students in centres far away from Lancashire.

The Lancashire Dynamo and Motor Company, Ltd., show an interesting exhibit of electrical machinery used in textile driving on their stand. This company strongly advocate the use of squirrel-cage induction motors for driving textile machinery because of their cheapness, simplicity and reliability. The "Lancashire" and "Crypto" induction motors are fitted with ball and roller bearings which possess the advantage of requiring very little lubrication and do not wear appreciably. The "Lancashire" centrifugal clutch has been designed to overcome the sole objection to the squirrel cage motor; *i.e.*, its low starting torque with a reasonable starting current. This system of starting has been successfully adopted in the case of a firm with over 850 b.h.p. of induction motors supplied from a turbine-driven power-plant of 1,500 kw. Although there are large motors, of which two are of 100 h.p. and six are of 80 h.p., in this installation, tests have been made of starting two or three of them at a time. This has been successfully accomplished without affecting the lighting supplied from the same generator.

Pipe-ventilated motors with "forced draught" have the advantage of remaining clean although placed in dusty and dirty surroundings. The air is washed before passing through the machine and is propelled by an external fan. These motors are shown driving machinery on many of the stands. The supply of electricity to the exhibition hall is 400 volt direct current, but to ensure a supply of alternating current for the driving of textile machinery on stalls in different parts of the hall, a 60 k.v.a. motor alternator set has been installed on the stand of this company to supply the demand. The visitors to the exhibition have thus the opportunity of seeing a complete sub-station plant at work, the electricity being controlled by switchgear made by Messrs. Brook, Hirst and Co., of Chester.

Messrs. Francis Shaw and Co., Ltd., of Corbett

EXHIBITS AT THE TEXTILE MACHINERY EXHIBITION AT MANCHESTER.

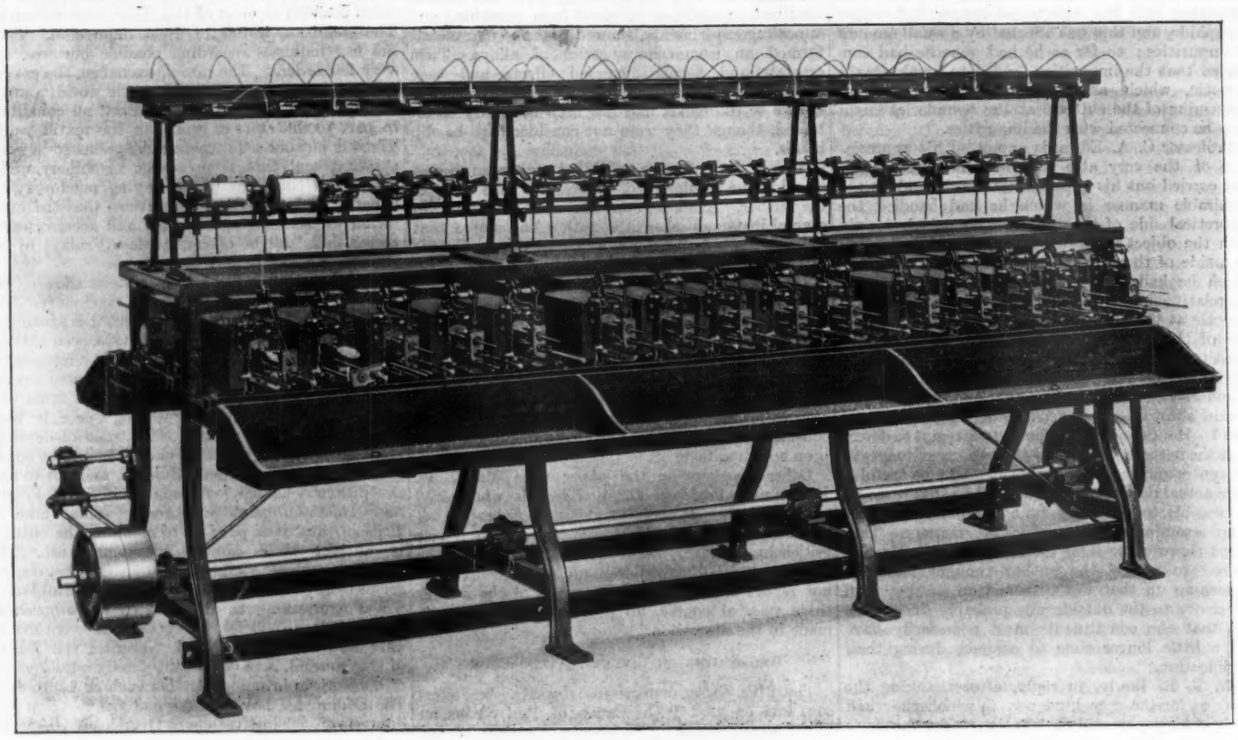


Fig. 1. Machine for Winding from Flanged Bobbins; Messrs. Schweiter, Horgen, near Zurich, Switzerland.

Street Ironworks, Bradford, Manchester, show on their stand instruments used to control automatically the temperature within any type of plant. These instruments, known as Tag controllers, make use of thermostatic bulbs filled with an easily vaporized liquid. The vapour pressure generated is passed by a flexible tube to a diaphragm fitting. The movements of this diaphragm are used to operate an air valve through which compressed air is passed to operate the steam valve. Not only are these instruments capable of maintaining steadiness of temperature within prescribed limits, but the application of a clockwork controlled cam to the system makes possible the control of the rate of heating up to the steady condition. The instruments are already in considerable use in rubber works and their use in textile factories for the control of the temperature of dye kettles, wool-scouring bowls, dryers or in fact in any plant where steam heating is employed for the purpose of boiling liquors or heating a vessel or chamber, should be productive of a great degree of regularity in working.

Messrs. Henry Livesey, Ltd., of Blackburn, and Messrs. Crowther, Ltd., of Port Street, Manchester, unite in the display of the manufactures of the Swiss firm of Schweiter. This firm, whose works are at Horgen, near Zurich, specialise in the production of winding machines, and 20 machines of different types are on exhibition. Two are illustrated by Figs. 1 and 2 annexed. The latter illustration shows a winding machine designed for winding from hanks and the former one for winding from flanged bobbins or cheeses. The machines are suitable for cotton, woollen, linen worsted and natural and artificial silks. The "Rapid" type of machine winds from bobbins, hanks or cops on to weft pirns or paper tubes. Each spindle works independently and can be run at speeds up to 4,000 r.p.m. The moving parts are all enclosed in oil baths. When the spindle is in motion the oil is thrown over the working parts to ensure complete and continual lubrication. The starting motion has the characteristic of giving slow working at the beginning and a gradual speeding up. Automatic

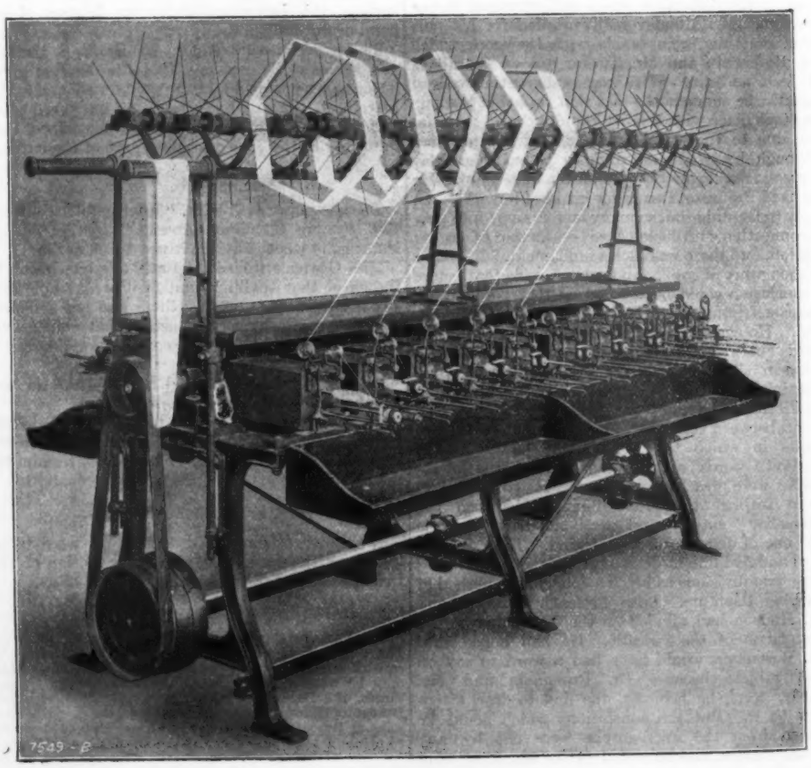


Fig. 2. Machine for Winding from Hanks; Messrs. Schweiter, Horgen, near Zurich, Switzerland.

EXHIBITS AT THE TEXTILE MACHINERY EXHIBITION.

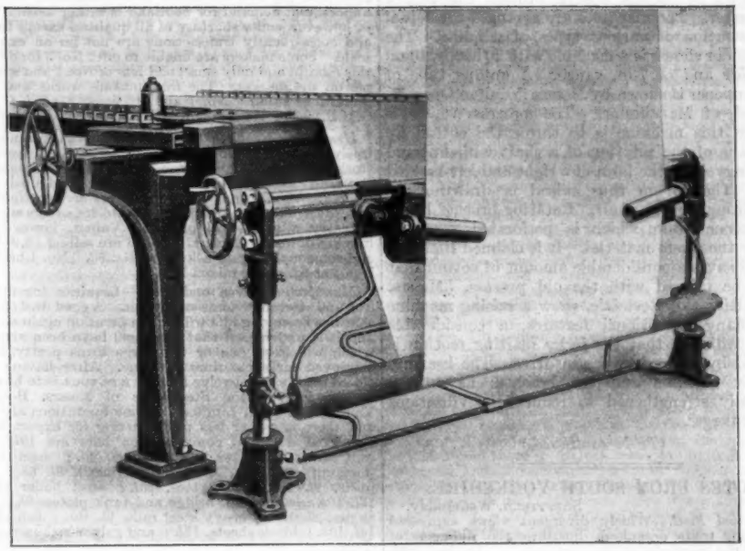


Fig. 3. Machine for Guiding Cloths to Mangles, &c.; Messrs. Daniel Foxwell and Son, Manchester.

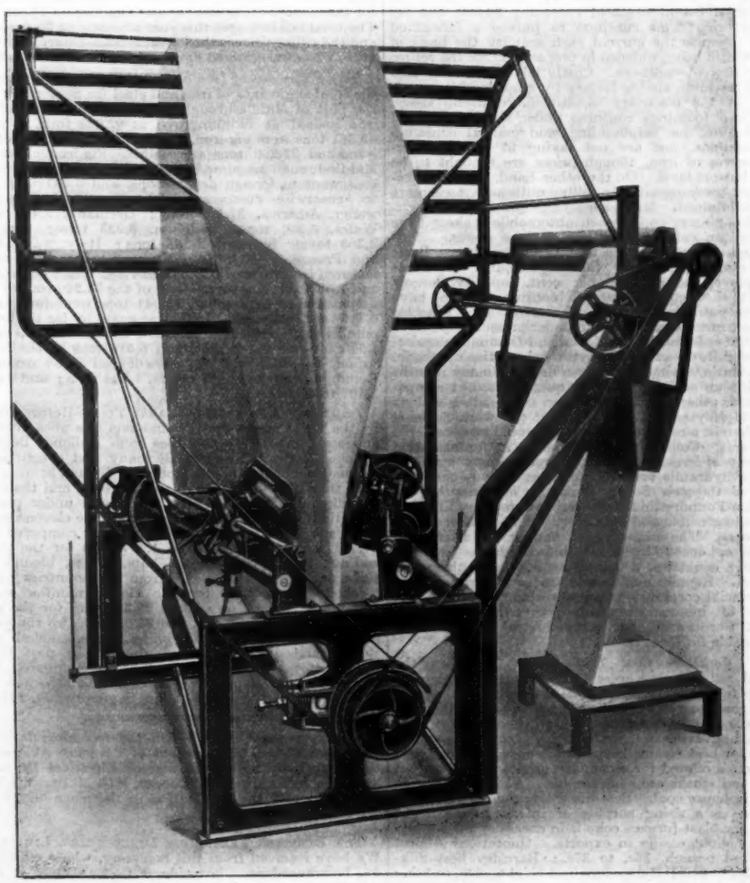


Fig. 4. Machine for Creasing Cloth; Messrs. Daniel Foxwell and Son, Manchester.

stop motions operate when a thread breaks and when the bobbin is filled.

Messrs. Daniel Foxwell and Son, of Cumberland-street, Manchester, show on their stand cloth-guiding machines suitable for many types of work, such as guiding cloth to mangles, drying machines, clip or belt stretchers and creasers. The machine illustrated by Fig. 3 on this page consists of a series of small rollers arranged in pairs. These rollers act upon the selvedges of the cloth and are put in and out of action by the position the selvedges take up. The action is obtained pneumatically. In the guider headstock there is a fixed brass roller under which and set parallel to it there is a rubber-covered roller fitted in a cradle. The headstocks lean downward from the back, and the air pressure which makes the rolls press together tend to pull the cloth outwards and upwards. Should the cloth come to the machine out of line the headstock to one side would have the advantage, and will pull the cloth over which causes the selvedge to press back a small lever which shuts off the supply of air, and thus the rubber roller falls away from the brass one and the other headstock pulls over the cloth to its proper position. In running, the air valves are operating repeatedly, but their action ensures the uniform guiding of the cloth. A machine for creasing cloth is shown by Messrs. Foxwell, and is illustrated by Fig. 4 on this page. In this case the cloth is fed over a V-shaped steel tube which gives it the required fold in the middle. It then passes double width through similar guider headstocks to those used on the guiding machine, and the middle of the piece is passed round a vertical aluminium cone roller. The material passes on through a pair of sycamore nip rollers on to a rolling and lapping or to a plaiting-down arrangement.

The original Nasmith combing machine was invented in 1901, and since then its use has extended until there are now about 9,000 of such machines at work. In the 20 years that have elapsed since that time there has been a great amount of investigation into the problem involved in successful and economic combing, and the new machine we illustrate represents the latest practice in its field. The disadvantage found with the earlier types of double machines was that both sides of the machine had to stop or to run together. The Nasmith twin combing machine, exhibited by Messrs. John Hetherington & Sons, Manchester, and illustrated by Figs. 5 and 6 on page 432, consists of two independent single machines built back to back, but driven by a single strap. In this plant each side may be stopped or started quite independently of its neighbour by means of clutches. The advantages accruing from the use of a machine of this type are economy of floor space and a reduction in the distance to be covered by the operative in the course of a day's work. As there are no back passages the setter can make all the common adjustments necessary with a combing machine while standing upright in front of the machine. The nipper, which is used to extract the waste fibres, can in this machine be set near to or far away from the rollers, and its relationship to the cylinder needles during combing never alters. These actions are obtained by the simple device of having the pivot on which the nipper swings set upon a lever pivoted on the boss of the cylinder shaft bearings. Each lever is connected by adjusting rods to a setting shaft, having a graduated sector on the end of it which indicates the amount of adjustment. Once all the nipper pivots have been set in line they can be moved simultaneously by turning the setting shaft in its bearings. This is performed by altering the distance between the nipper and the detaching rollers, without changing the distance between the nipper and the needles. Increased life of the leather covering of the top rollers, the almost complete abolition of strain in the driving mechanism when starting or reversing the rollers, reduction in the loss of long fibres with the waste, and the power to work very heavy laps are obtained by the variable weighting of the detaching rollers. The combing cylinder in use is 6 in. in diameter, with 20 rows of needles, and the drawing heads have five lines of rollers. In addition to enhanced power in dealing with the finest work, the machine is capable of dealing with low waste from grades of combings which were not attempted

formerly. The machine is shown in operation, with three kinds of combing of Egyptian cotton on one side and American cotton on the other.

Messrs. Dobson and Barlow, of Bolton, show a patent Tunstall combing machine on their stall. It is a double combing machine with six heads on each side. One of the features of the machine which distinguishes it from others is that no cams are used to actuate the nippers, top comb or detaching roller mechanism. The two sides of the machine are entirely interdependent; the nipper mechanisms for the removal of waste fibre on each side are bonded together and actuated by a single swing shaft. The top combs are entirely independent of the nippers. They are set to the detaching rollers and their position need not be altered for a change in the percentage of waste. The Roth aspirator is included as part of the standard equipment. The waste is drawn on to two perforated rotating tubes by a fan placed under the main gearing. The machine shown has a capacity of combing from 1,100 to 1,300 lb. of cotton in a 48-hour week.

Humidifiers of almost every description are shown on various of the stands. The air and water jets system of humidifying is shown on the stand of The Andrew Machine Construction Company, of Stockport. A complete installation has been fitted up for demonstration purposes. Messrs. James Gordon and Co., Limited, demonstrate their "Air Flow" system and also exhibit various interesting models of water-turbines and steam superheaters. A range of steam power station accessories, such as feed-water regulators, water flow recorders, and draught gauges, are also shown here. The Airton Engineering Co., Limited, of Bell Busk Mills, near Leeds, show a complete ventilation and humidifying installation, which makes use of a powerful fan to draw air through a duct from outside. The atomiser is partially submerged in a water container, and if any drops of water pass away with the air they are trapped at a false lip on each of the outlet pipes, and restored to the general water available for atomising.

A self-contained plant for air purification is shown on the stand of Messrs. Herbert Smethurst and Sons, Limited, of John Dalton-street, Manchester. In this exhibit air is drawn in by a fan, and cleansed by passing through a water spray. Another exhibit here is a combined air and water jet system of humidification. Messrs. Cleworth, Wheal and Co., Limited, of Castleton, show an exhibit consisting of a small unit humidifier, a small air cooler, and a small water cooler. The humidifier consists of a centrifugal fan for propelling the air, and air and water heaters. The water storage tank contains the patent surfaces peculiar to the firm's system.

Auto-seal valve and ball-bearing "dollheads" for maintaining steam and watertight joints for the cylinders of textile machines are also shown on this stand. They replace packing and do not require the same continual attention and renewal.

Hosiery machinery for neck-ties and stockings is shown by Messrs. G. Stibbe and Co., Ltd., Leicester. Ferodo brake linings and stair treads are also shown by the firm.

Messrs. Laminated Gears Limited, have a stand where they show combined reducing sets consisting of motor gears and bedplate. The silence and smoothness of the drive is well demonstrated in the examples. A model consisting of a "Parkinson" 8 h.p. squirrel cage motor with a "Broadbent" centrifugal clutch combined with "laminated" gear drive to a brake drum is shown by Messrs. Thomas Broadbent and Sons, of Huddersfield, on the same stand, and is used to demonstrate the ease with which the motor accelerates without load, and how the clutch automatically operates to pick up the load. The "Klincha" system of belt lacing, and many accessories such as file-cleaners, are exhibited by Messrs. W. T. Nicholson and Clipper Company, Limited, of Salford. Tachometers and tachographs, transmission dynamometers and textile testing apparatus are shown by Geo. Thomas and Co., Limited, of Deansgate, Manchester.

Messrs. Hans Renold, Ltd., Manchester, exhibit their specialities, and show modern practice in line shaft drives for textile mills by the replacement of spur and bevel gear drives by chains. The Field Tube superheater and various types of tubing for steam and exhaust connections and feed water are shown by Messrs. Boltons Superheater and Pipe works, Stockport.

Winding machines of types suitable for hosiery yarn, high speed pirn winding and "close" winding are shown by Messrs. Joseph Stubbs, Limited, of Manchester. The machines are arranged for actual demonstration of various types of winding. The pirn winder shown is a machine with 20 heads, 10 on each side and of 7-in. gauge. A unique type of cotton opener is shown by Messrs. Youlten Openers, Limited, of Manchester. The process which is used on this machine is to throw the cotton up by means of the rotation of a shaft with fingered stampings set in the form of a right and left-handed helix. The cotton thus raised is drawn away by a strong current of air. Rotating brushes below the opener drum, which is perforated, serve to remove the waste material. It is claimed that this method saves a considerable amount of cotton that would be injured with the old process. Messrs. T. W. Riley, of Rochdale, show a raising machine with many exceptional features, a considerable one of which is that the jerky plaiting motion is replaced by a steady uniform drive. The bearings of this machine and the brackets have been materially strengthened to reduce the vibrations and breakages.

(To be continued.)

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—Widely divergent views expressed by leading trade organisers illustrate the difficulty of gauging the industrial outlook accurately. In the South Yorkshire heavy trade some very pessimistic forecasts are given by men like Mr. Charles Markham, who predicts a very slow recovery and a winter of severe hardship. On the other hand, the new Master Cutler (Mr. R. W. Matthews) who is intimately in touch with steel and engineering matters, considers that those who have maintained a spirit of quiet optimism are about to be justified. It is significant, however, that in face of an unemployed list in Sheffield exceeding 39,000, the big manufacturing firms continue to pursue a farsighted policy. Despite the current cash scarcity the basis of output is still being widened in preparation for the return of more active conditions. Costly laboratories are also pushing research, aiming largely by quantitative experiments, at the discovery of still more useful steels. Forges and foundries continue under the influence of depression in the shipbuilding and general constructional sections, and are not laying in any considerable reserves of iron, though prices are thought to be at rock bottom level. On the other hand, the improvement last week reported in rolling mills activity is more than maintained. Mills supplying Lincolnshire agricultural engineers and French automobile makers have completed an uninterrupted run of three weeks. This comprised a record for the past twelve months. Basic steel is also in constantly widening demand. Furnaces are employed at fully 60 per cent. capacity, largely to meet the requirements of consumers who have ceased to patronise Continental sources. The Lincolnshire blast furnaces are working under pressure, and have substantial order books. Colonial and Dominion requirements of railway axles and tyres are on the up grade. Foreign markets which have been dead for many months are taking an active interest in quotations, but competition from other districts and from competitive makers abroad is very severe, and much of the work is being undertaken at a rate which normally would be considered uneconomic. Colliery plant is coming in for attention now that coal owners are doing a larger export business. Complete hydraulic tub-decking plant is to be supplied to one of the new South Yorkshire collieries by the Brightside Foundry and Engineering Company, Limited. Business in crucible and high-speed steel is still in a state of suspense. The difficulty of finding an alternative outlet is enhanced by heavy import duties in steel-consuming countries, which, pre-war, were substantial customers. Repairs and extensions to tramway tracks for provincial corporations are absorbing a considerable tonnage of manganese steel, points and crossings. Sheffield Corporation has ordered steel switches and electric cable for local trams.

South Yorkshire Coal Trade.—The fact that the principal railway companies have arranged locomotive contracts for the last three months of the year on the same basis as that formerly operated is taken as an indication that the collieries may be induced to postpone contemplated advances in manufacturing fuels. The export demand for best steams keeps prices at a firm level, but special rates offered for secondary grades fail to attract buyers, and stocks are considerable. A similar position obtains in house coal. Best qualities are a good market but there is a rising surplus of inferior sorts. The demand for blast-furnace coke is in excess of the supply, despite a slight easing in exports. Quotations:—Best handpicked branch, 36*s.* to 37*s.*; Barnsley best Silkstone, 33*s.* to 34*s.*; Derbyshire best brights, 24*s.* to 25*s.*; Derbyshire best house, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire best large nuts, 19*s.* to 21*s.* 6*d.*; Derbyshire best small nuts, 15*s.* to 16*s.* 6*d.*; Yorkshire hards, 21*s.* to 22*s.*; Derbyshire hards, 19*s.* to 20*s.* 6*d.*; rough slacks, 8*s.* 6*d.* to 10*s.* 6*d.*; nutty slacks, 7*s.* 6*d.* to 8*s.* 6*d.*; smalls, 3*s.* to 5*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—American buying of Cleveland pig-iron continues notwithstanding the tariff impost, and demand for Scotland is rather keen. There is, however, acute shortage of all qualities except forge 4, and consequently transactions are not on an extensive scale. Some makers are unable to offer No. 3 for delivery this month, and only small odd lots of No. 1 and siliceous are on the market. The f.o.t. makers' works and f.o.b. quotations stand: No. 1 and siliceous, 97*s.* 6*d.*; No. 3 G.M.B., 95*s.*; No. 4 foundry, 90*s.*; and No. 4 forge, 85*s.*

Hematite.—East coast hematite is being taken up more freely on both home and foreign account, and makers' stocks are being drawn upon to meet requirements, but the statistical situation still leaves a good deal to be desired. Whilst one or two producers are now fairly off for orders, and have practically no stocks, others continue to carry a good deal of iron. Values, however, are moving upward. Nos. 1, 2 and 3 are selling at 90*s.* 6*d.*, and some makers now ask up to 92*s.* 6*d.* No. 1 hematite is put at 6*d.* above mixed Nos.

Manufactured Iron and Steel.—Inquiries for finished iron and steel show some expansion. A good deal of plant that has been long idle will be in operation again shortly, and it is understood that contracts have been arranged which will keep one or two large firms pretty busily employed for some time to come. After having been closed for the past twelve months a re-start is to be made at the large Eston Steelworks of Messrs. Bolckow, Vaughan and Co., Limited. Home quotations are firm, and there is rather less price cutting for export trade. For local delivery, common iron bars are 10*l.* 10*s.*; iron rivets, 11*l.* 10*s.*; steel bars, 9*l.*; steel billets (medium), 7*l.* 10*s.*; steel billets (hard), 8*l.* 5*s.*; steel joists, 9*l.* 10*s.*; steel tees, 10*l.*; steel boiler plates, 12*l.* 10*s.*; steel ship, bridge and tank plates, 9*l.*; steel angles, 8*l.* 10*s.*; heavy steel rails, 9*l.* 10*s.*; fish plates, 14*l.* 10*s.*; black sheets, 12*l.*; and galvanised corrugated sheets, 16*l.* 10*s.*

Ironworkers' Wages.—The accountants to the Board of Conciliation and Arbitration for the Manufactured Iron and Steel Trade of the North of England have certified the average net selling price of bars and angles for the two months ending August 31 last at 10*l.* 12*s.* 11·90*d.* per ton, as compared with 11*l.* 8*s.* 0·27*d.* per ton for the previous two months. Under sliding scale arrangements this reduces puddling and other forge and mill wages for the months of September and October by 7½ per cent. The total fall in wages this year amounts to 30 per cent., and the selling price is the lowest recorded since February, 1916, when the certified figure was 10*l.* 14*s.* 4·6*d.* per ton.

Tees Shipments of Iron and Steel.—Official returns give the total shipments of iron and steel for September from the port of Middlesbrough, including 4,928 tons of pig-iron cleared at Skinningrove, at 92,038 tons, of which 65,361 tons were pig-iron, 2,417 tons were manufactured iron, and 24,260 tons were steel. Pig-iron cleared at Middlesbrough amounted to 60,433 tons, of which 51,996 tons went to foreign destinations, and 8,437 tons went to coastwise customers. The principal importers were: America, 31,119 tons; Germany, 8,460 tons; Wales, 5,600 tons; Belgium, 3,933 tons; Scotland, 2,363 tons; Sweden, 2,255 tons; Italy, 2,205 tons; and France, 1,695 tons. Of the 2,417 tons of manufactured iron shipped last month 1,382 tons went abroad, and 1,035 tons coastwise; and of the 24,260 tons of steel despatched in September, 18,041 tons went foreign and 6,219 tons coastwise. India was again by far the largest purchaser of both manufactured iron and steel, taking 1,303 tons of the former, and 6,519 tons of the latter. Among the other chief importers of steel were: Argentine Republic, 1,951 tons; Victoria, 1,904 tons; and Japan, 1,497 tons.

Imports of Iron and Steel to the Tees.—Returns issued by the Tees Conservancy Commission this week give iron and steel imports to the Tees from Holland, Belgium, France, Norway, Sweden, Germany and coastwise for the eleven months ending September 30 last, as compared with the same eleven months of 1920–21, and the corresponding period of 1913–14 which was under pre-war conditions. Pig-iron imported during the eleven months just ended amounted to 34,681 tons, as compared with 57,782 tons a year ago and 1,427 tons for the period ending 1914. Crude sheets, bars, billets, blooms and slabs unloaded on Tees-side from the countries named reached 50,264 tons for the eleven months ending September 30 last, as against 28,323 tons for the same eleven months a year ago, and 33,655 tons for the period ending September, 1914. Plates, bars, angles, rails, sheets, and joists imported during the past eleven months totalled only 6,111 tons as compared with 20,191 tons for the same time twelve months ago, and 19,481 tons for the period ending September 30, 1914.

"Science Abstracts."—On the recommendation of the Committee of Management of "Science Abstracts," the Council of the Institution of Electrical Engineers have appointed Mr. W. R. Cooper, M.A., B.Sc., M.I.E.E., to be editor of the publication in the place of the late Mr. L. H. Walter.

The Business Telephone Directories, Limited.—We have received from this company, whose offices are 25, Lawrence-lane, Cheapside, E.C. 2, a copy of their "Buff Book" of telephone numbers arranged according to trades. This now includes an Hotel Section at the end of the book, which gives the names of all the principal hotels in the British Isles, the Continent, Egypt, &c., some 6,000 hotels in all. The company state that a copy of the book is being sent to each one of these hotels.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—There has been little movement in the Scottish steel trade during the past week, and although the prospects seemed better on account of an improvement in the general inquiry, little result has been forthcoming. The position at present is very much of the "as you were" state. Bookings all round have been very poor lately, as buyers have little confidence in markets and absolutely refuse to commit themselves beyond actual necessities. The outlook for the oncoming winter is very dark, and the ballot now being taken amongst the shipyard workers regarding their acceptance of the withdrawal of the remaining 10*s.* of the 26*s.* 6*d.* war bonus is of great importance to the steel trade. Should the workers accept, there are prospects of more shipbuilding contracts with a resultant demand for steel plates, &c., but in the event of an adverse vote not only will new orders not be placed, but most of the recently-intimated contracts will either be cancelled or hung up pending a more favourable building opportunity. In most of the cases above mentioned these orders were tendered for and accepted on the assumption that the men would agree to the proposed cut of 10*s.* in their wages, thus reducing the cost of construction and enabling the masters to quote a much lower price for the new vessels. Meantime ship plates and also sectional material are moving very slowly. In the black sheet trade interest is chiefly centred round export orders for the thinner gauges and heavies are not in much demand. Prices are nominally unchanged.

Malleable Iron Trade.—The state of the malleable iron trade of the West of Scotland shows no change for the better yet. Local consumers are passing on few orders for bar iron because of the general depression, and there is also a very small demand for export. The price for "crown" bars is still 10*l.* 10*s.* per ton, delivered Glasgow.

Scottish Pig-Iron Trade.—Quite a healthy tone still prevails in the pig-iron trade of Scotland, and the output is being rapidly disposed of owing to the fairly large quantities being shipped to America. The demand from that quarter is not now so insistent, but orders on hand will take up quite a respectable tonnage yet, and by the time these are worked off the home demand may have improved. Arrangements for the restarting this week of two furnaces, on foundry quality, at the works of Messrs. William Dixon, Limited, Govanhill, Glasgow, were satisfactorily come to by the workers agreeing to accept certain proposals made by the firm. Another restart is that at Lugar, where Messrs. William Baird and Co., Limited, are relighting three furnaces, which will bring the total number in blast in Scotland up to 31. All of these are on foundry grades except three—two at Gartsherrie and one at Clyde Iron Works—which are on hematite. Prices continue firm and are as follow:—Hematite, 5*l.* 7*s.* 6*d.* per ton, delivered at the steel works; foundry iron No. 1, 5*l.* 5*s.* per ton, and No. 3, 5*l.* per ton, both on trucks at makers' works.

Scottish Shipbuilding.—The shipbuilding output from the different districts in Scotland during last month was quite a fair average and totalled 17 vessels of 44,320 tons, made up as follows:—

	Vessels.	Tons.
The Clyde	11	34,915
The Forth	2	1,747
The Tay	1	3,445
The Dee and Moray Firth ...	3	4,213
Total	17	44,320

The Clyde output was the third highest for the year to date, but was the lowest for the month of September for many years and only brings the nine months' total up to 101 vessels of 289,218 tons. That figure is the lowest since the year 1909, and not only is it 60,798 tons behind the corresponding period of last year, but it is over 200,000 tons less than for the same period of 1920 when the figure was 489,425 tons. Two items of much importance mark the month of September in the shipbuilding industry, these being the opening of negotiations between the employers and their workers with regard to the withdrawal of the last 10*s.* of the 26*s.* 6*d.* war bonus, and the placing of orders for about a dozen new vessels. The latter are almost all dependent on the former, and if the ballot now in progress should result in the men coming to terms then all will be well and other contracts will probably be placed. The next meeting of the employers and the men's representatives takes place in Edinburgh on Tuesday, but the result of the ballot will very likely be public property by the end of this week. It is safe to say that the whole of the commercial world of the West of Scotland is intensely interested in this week's ballot and the resultant negotiations next week because of the great bearing which shipbuilding has on the prosperity or otherwise of general trade in this area. If satisfactory terms are arranged and the cost of production is thus reduced, contracts for new tonnage will increase, and a large amount of trade depression will pass away.

INCOME-TAX GUIDE.—At the present time, when the tax weighs so heavily upon one's income and upon the savings of past years—in those instances where thrift and abstinence have rendered these latter possible—it is useful to have a guide book which assists one in checking the income-tax demand note. Such an aid is afforded by the "Income-Tax Guide," which is published at the price of 1*s.* net by *The Financial Times*, 72, Coleman-street, E.C. 2, a pamphlet of 40 pages, which covers income tax, super-tax, &c., and will be found serviceable both by individuals and corporations or companies.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Terms for a settlement of the stoppage of the collieries and ironworks of the Ebbw Vale Steel, Iron and Coal Company, Limited, which rendered idle some 12,000 men, have been arranged, but so far work has not been restarted. The clause in dispute in respect to allowances has been referred to Dr. Galloway, the arbitrator, and the miners have given an undertaking to accept Dr. Galloway's interpretation of the clause in question, and also a guarantee that will ensure continuity of employment at the coke and by-product plant, and that there shall be no cessation of work without proper notice. In connection with the demand of the Miners' Federation for extra allowances in South Wales for the lower-paid men Lord Buxton, the independent chairman of the Coal Board, who was called in, has fixed a minimum limit of 7*s.* 2*d.* per day and divides the workers into classes, those with dependents and those without. The maximum for those without dependents is 6*s.* 8*d.* per day. A youth between 18 and 21 years, whose wages at present do not exceed 5*s.* 0*d.* per shift, and who come within the class of workers supporting families, are to receive an extra 6*d.* per shift for each shift worked, and of 3*d.* per shift worked if he is a worker not contributing to the support of dependents. The new allowance is not to be paid to any worker in any one week in respect of more than six full shifts, or the equivalent in time worked, and no worker is entitled to receive these allowances during any week in which he is voluntarily absent from work from one or more shifts without reasonable cause. These extra allowances are estimated to involve an addition of between 30,000*l.* and 40,000*l.* per month in the cost of production. The certificate of the joint accounts showing the result of the Welsh coal trade in August, when the bank holidays intervened and caused a reduction of 600,000 tons in output, showed that after allowing for the owners' standard profits of 17 per cent. there was a surplus of 201,494*l.* from which had to be deducted the deficiency of 49,914*l.* brought forward from July, leaving a net surplus of 151,580*l.* The proceeds were, however, insufficient to pay the minimum wage of 28 per cent. on the base rates without the owners sacrificing 217,611*l.* out of their standard profits, which brings the total sacrificed since November last by the owners to 2,559,000*l.* The proceeds in August showed an increase of 1*s.* per ton over July, but the wages and "other costs" were practically unchanged. Exports of coal from South Wales last week totalled 570,463 tons, or nearly 8,000 tons less than in the previous week. Of the total, 163,859 tons, or 29 per cent. of the whole, went to the United States and Canada, 130,776 tons going to the United States and 33,083 tons to Canada. Since July 29 last Welsh coal to the amount of 1,283,734 tons has gone to North America, while 206 steamers to carry 1,495,550 tons have been chartered, so that something like 200,000 tons is still to be shipped. The market has developed a steadier tendency during the past week, though actual prices show no change.

BRITISH COMMERCIAL GAS ASSOCIATION.—This association will hold its eleventh annual general meeting and conference in the lecture theatre of the Museum and Art Gallery, Bristol, on the 16th to the 18th inst., when a number of papers are to be read and discussed.

THE INSTITUTE OF METALS.—This Institute has issued a folding card giving the particulars of the forthcoming meetings of the various local sections. The sections are those of Birmingham, London, Newcastle-on-Tyne, Glasgow and Sheffield. The secretary of the Institute, Mr. G. Shaw-Scott, announces that steps are now being taken to form a South Wales local section at Swansea. It will be remembered that the Mayor of Swansea, when welcoming the members at the meeting of Wednesday, September 20, referred to Swansea as "the greatest metallurgical centre in the world." This being the case, the local section of the Institute in that city should count more members than any of the other local sections. We trust that men employed in the South Wales metal industries will bear in mind the mayor's statement and will join the new Swansea local section in large numbers. The card further announces that the next London annual general meeting will be held on March 7 and 8, also that the annual May lecture will be delivered on May 2, by Dr. Rosenhain.

THE RAILWAY WORKERS' INTERESTS.—We have received from the Great Western Railway Company a copy of a little book, a copy of which is being distributed to each employee. This pamphlet is entitled "My Railway and Me: Six of One and Half a Dozen of the Other," and we hope it may be instrumental in convincing the staff that their interests are bound up with those of the company. The book commences with a couple of chapters which take the form of a dialogue, the subject just dealt with being "Economy: Whose Concern is it?" In the second chapter the argument is turned so as to show how the position of the workers is bound up with that of the shareholders. There follow chapters consisting of "Economy" hints for the staff, some of a general nature and others particularly addressed to special grades like the locomotive men or the road motor staff. The little suggestions are tersely phrased and, glancing through them, they are seen to cover economies both large and small. The effort to stimulate the co-operation of the worker deserves success, for we are convinced that nothing but good can follow from the realisation on the part of the worker that his interests and those of the company are identical.

NOTICES OF MEETINGS.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, October 7, at 2 p.m., in the Lecture Theatre of the Institute, Newcastle-on-Tyne. The following papers will be read and discussed: "The Development of Metal Supports for Mines," by Mr. John Roberts; "Aerial Wire Ropeways," by Mr. R. S. Tate, B.Sc.

THE MANCHESTER METALLURGICAL SOCIETY.—Tuesday, October 10, at 7 p.m., in the College of Technology, Whitworth-street, Manchester. Presidential Address by Mr. W. Webster Wilson.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, October 10, at 5.30 p.m., at the Rooms of the Chemical Society, Burlington House, Piccadilly, W. 1, a paper will be read by Dr. A. E. Dunston, D.Sc., F.I.C., F.C.S., on "The Work of the Standardisation Committee."

THE INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—Autumnal General Meetings. October 10 and 11, at Caxton Hall, Westminster, S.W. 1. Tuesday, October 10, at 8.15 p.m., paper on "Some Points in the Law of Heating Engineers' Contracts," by Mr. Robert Fortune. Wednesday, October 11, at 3 p.m., "Heating and Ventilating of Passenger Ships," by Mr. J. L. Musgrave.

THE INSTITUTE OF INDUSTRIAL ADMINISTRATION.—Tuesday, October 10, at 8 p.m., at the London School of Economics. Captain H. Riall Sankey on "Training for Administration in Industry."

THE ASSOCIATION OF ENGINEERS-IN-CHARGE.—Wednesday, October 11, at 7.30 p.m., at St. Bride's Institute, Bride-lane, Fleet-street, E.C. 4. Presidential Address by Dr. H. S. Hele-Shaw, F.R.S., on "The Advantages of Incorporation."

THE OPTICAL SOCIETY.—Thursday, October 12, at 7.30 p.m., at the Imperial College, when the following papers will be presented and discussed: (1) "A Physical Study of Coma," by Mr. L. C. Martin, D.Sc., A.R.C.S.; (2) "The Structure of Sand-Blasted and Ground Glass Surfaces," by Mr. F. W. Preston, B.Sc. (Taylor, Taylor and Hobson, Research Department). There will also be exhibited a new chemical spectrometer by Messrs. Adam Hilger, Limited.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, October 13, at 39, Victoria-street, Westminster. Paper, "Artificial Ice-Making," by Mr. E. C. West (Member).

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Wednesday, October 11, at 8 p.m., at the Royal Automobile Club, Pall Mall, when Lieutenant-Colonel D. J. Smith will deliver his Presidential Address, entitled "The Need for a Wider Outlook in Automobile Engineering."

THE INSTITUTION OF NAVAL ARCHITECTS.—The Elgar Scholarship in Naval Architecture (1922) has been awarded by the council of the Institution to Mr. William Sprague, of H.M. Dockyard, Devonport, and the Earl of Durham prize to Mr. F. F. Crocombe, of H.M. Dockyard, Portsmouth.

THE IRON AND STEEL INSTITUTE.—This Institute has now issued Vol. CV of its Proceedings, which gives the papers read and discussions held on these at the last spring meeting, together with abstracts of articles published in home and foreign journals, dealing with the metallurgy of iron. The book covers 712 pages and contains numerous illustrations.

STEAM CONDITIONS IN MODERN POWER STATIONS.—We have received from the English Electric Company, Limited, Queen's House, Kingsway, W.C. 2, a reprint of an article on "The Choice of Steam Conditions in Modern Power Stations," by L. C. Kemp, B.Sc.(Eng.), A.M.Inst. C.E., a copy of which the company are willing to send to anyone on request.

THE INSTITUTION OF MECHANICAL ENGINEERS.—This Institution has issued Vol. I of its proceedings from January to May, 1922, a book of about 700 pages. It opens with the annual report of the council for the year 1921, and gives the papers which were read during the period from January to May, with the discussions thereon; also a number of papers which were selected for publication.

DIESEL ENGINE USERS' ASSOCIATION.—At the next meeting of the Diesel Engine Users' Association on Friday, the 27th inst., to be held at the Institution of Electrical Engineers, a paper on "The Care and Maintenance of Diesel Engines" will be discussed. The subject will be introduced by Mr. G. E. Windeler, M.I.Mech.E. Non-members interested in the subject and desirous of attending the meeting can make application for tickets of admission to the Honorary Secretary, 19, Cadogan Gardens, S.W. 3.

UNIVERSAL DIRECTORY OF RAILWAY OFFICIALS, 1922.—This directory for the present year, the twenty-eighth year of publication, is compiled under the direction of the editor of *The Railway Engineer*, and is issued by the Directory Publishing Company, Limited, 33, Tothill-street, S.W. 1, at the price of 20*s.* net. It gives general information on all the railways of the world, together with the names of the principal officials of each. The contents are indexed under countries, names of railways, tramways (British) and railway institutions, and also under the names of the officials.

TWIN COMBING MACHINES AT THE TEXTILE EXHIBITION, MANCHESTER.

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(*For Description, see Page* 429.)

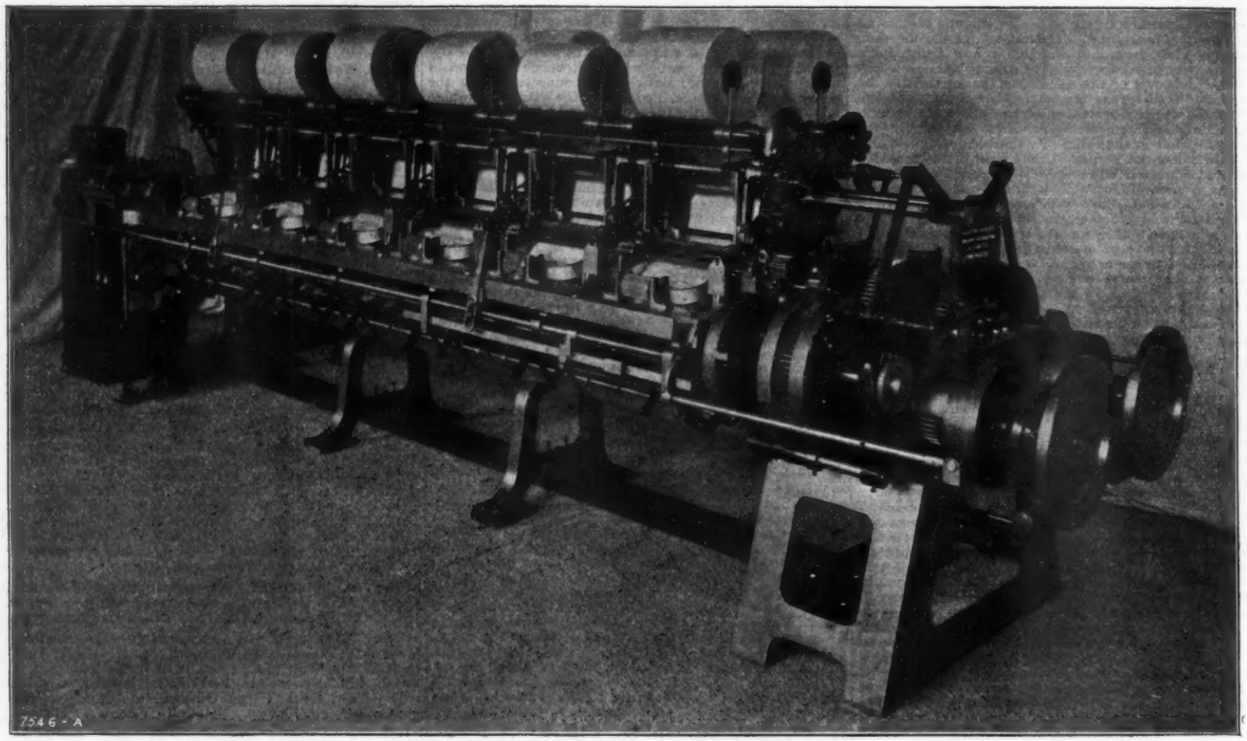


Fig. 5.

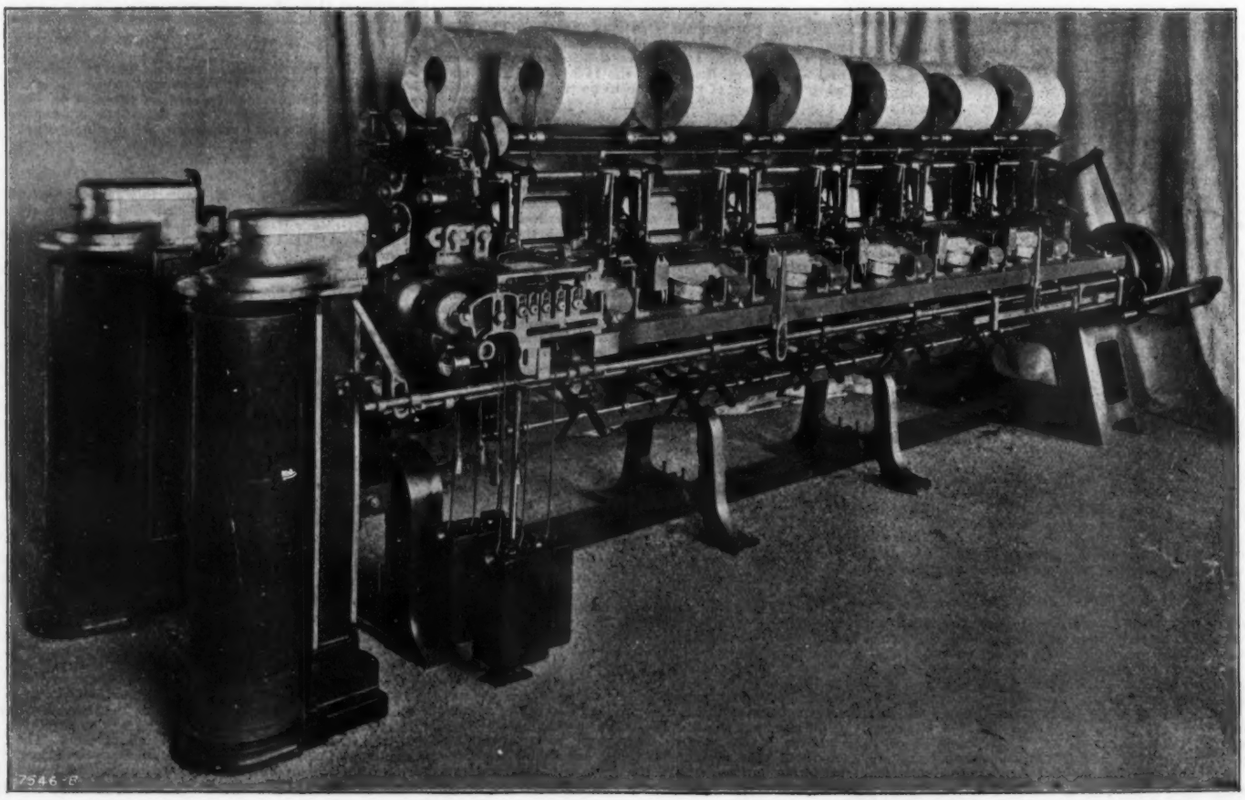


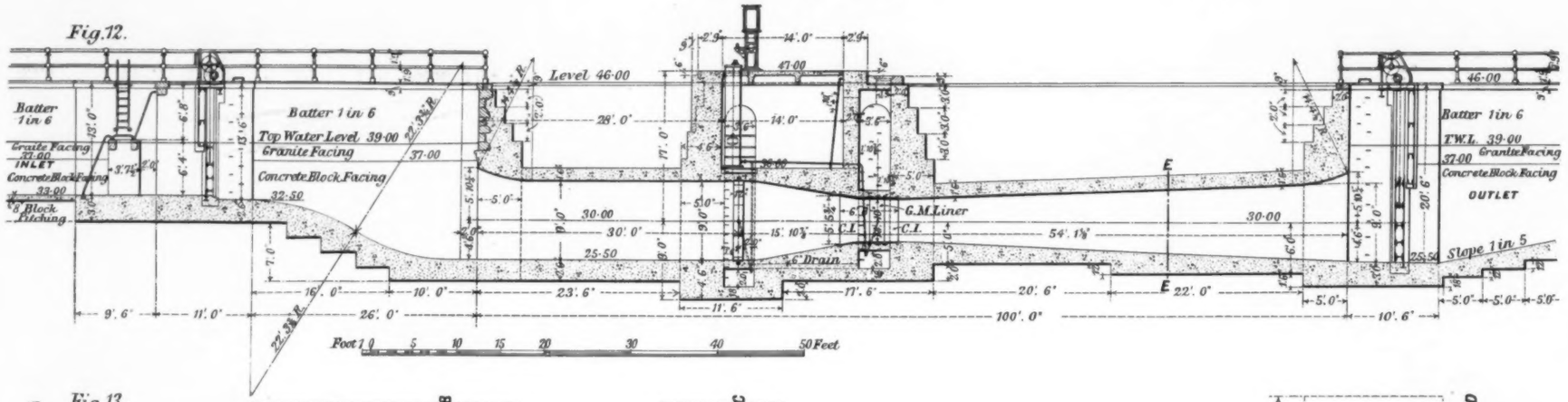
Fig. 6.

INTAKE WORKS OF THE LITTLETON RESERVOIR.

MR. H. E. STILGOE, M.INST.C.E., CHIEF ENGINEER TO THE METROPOLITAN WATER BOARD, ENGINEER.

(For Description, see Page 417.)

Fig.12.



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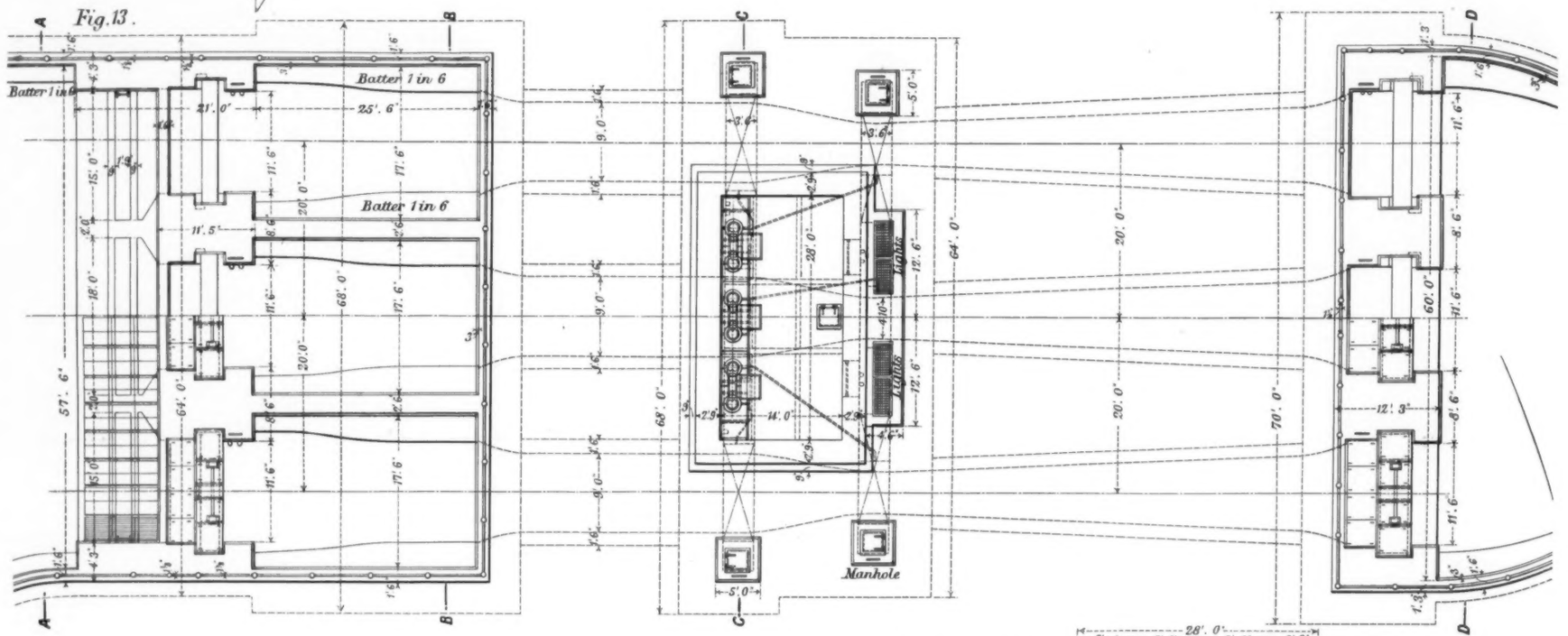
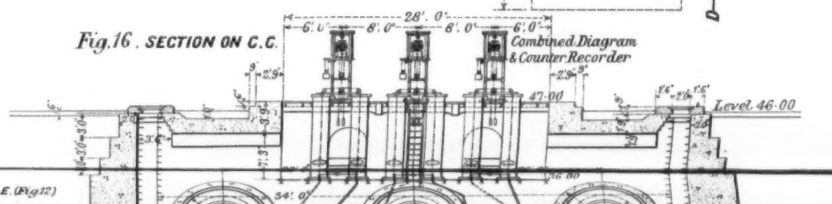
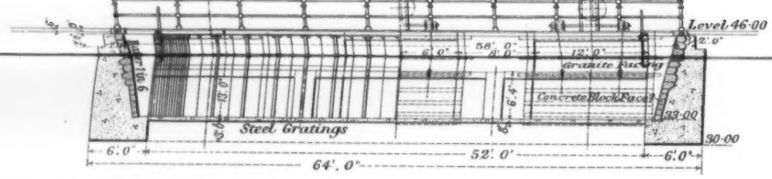


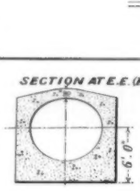
Fig.14. SECTION ON A.A.

SECTION AT E.E. (Fig 12)

Fig.16. SECTION ON C.C.







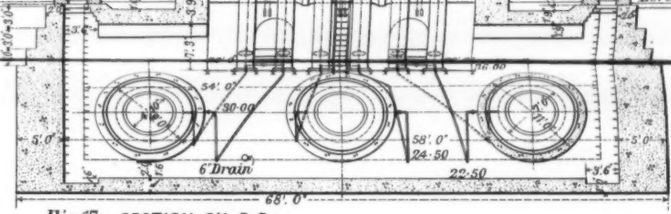


Fig.15. SECTION ON B.B.

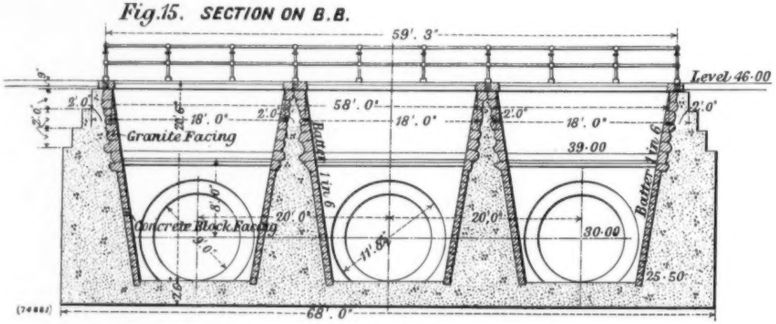


Fig.17. SECTION ON D.D.

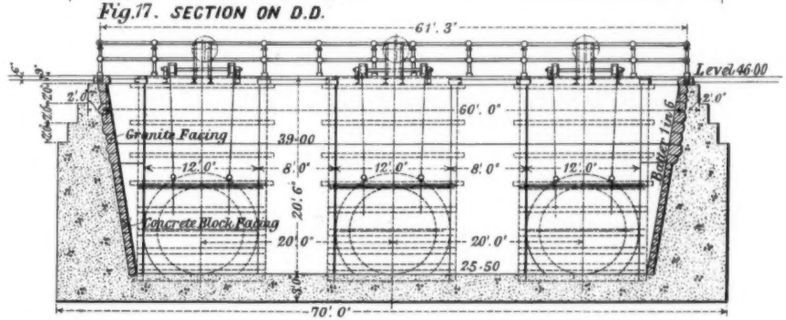


Fig.18.

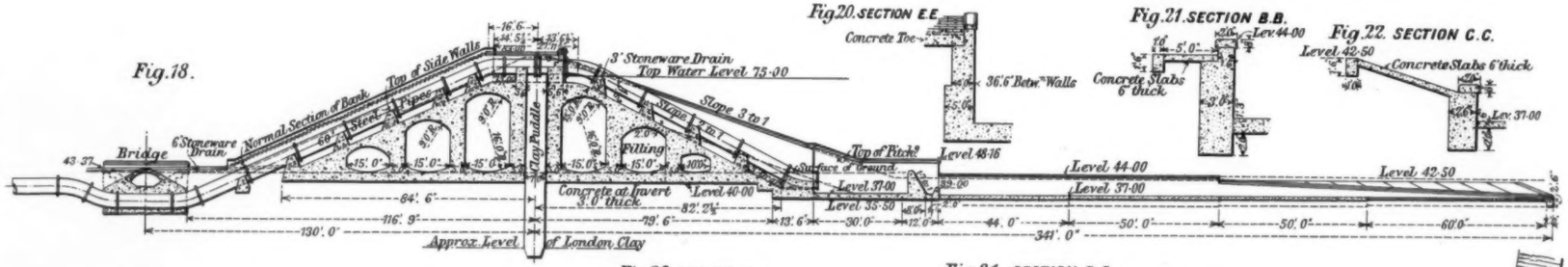


Fig.20. SECTION E.E.

Fig.21. SECTION B.B.

Fig.22. SECTION C.C.

Fig.19.

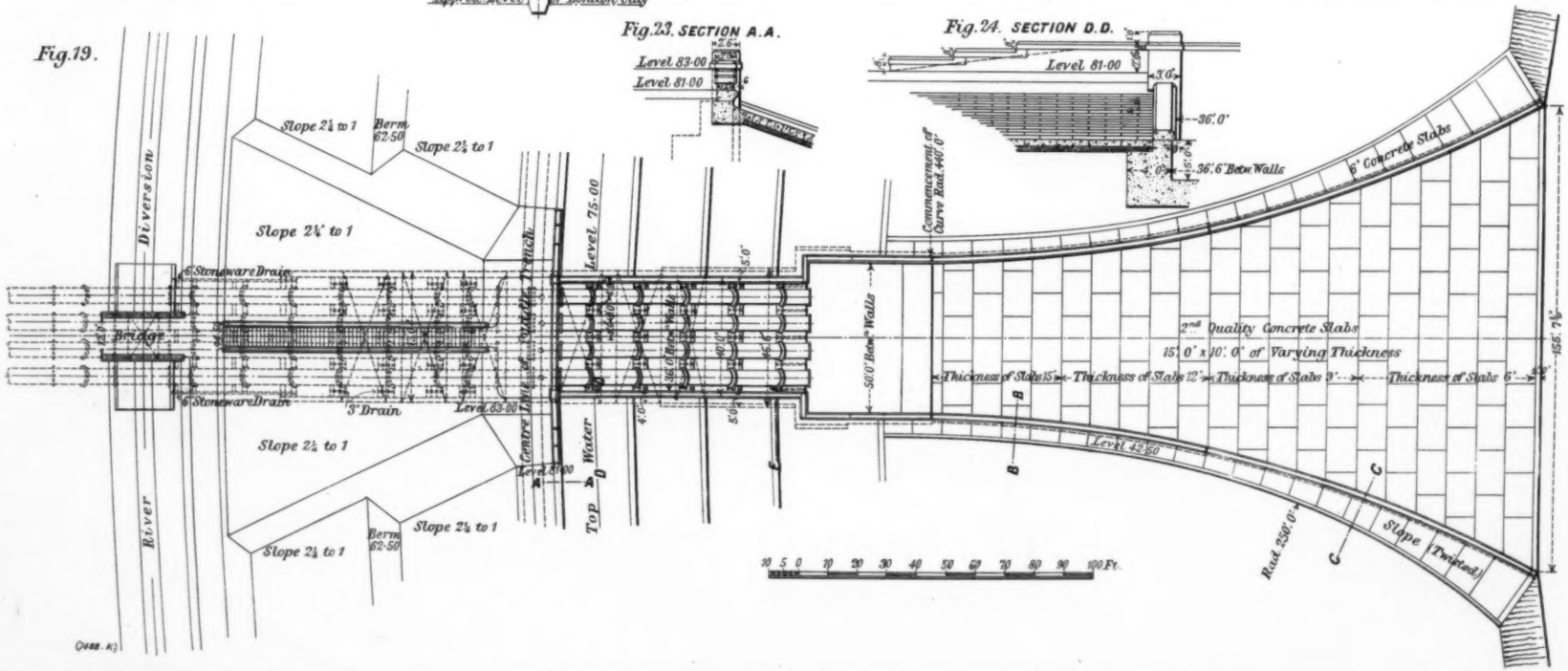


Fig.23. SECTION A.A.

Fig.24. SECTION D.D.

ENGINEERING.

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TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

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CONTENTS.

	PAGE
The Littleton Reservoir for the Metropolitan Water Board (*Illus.*)	417
The British Association	419
The Relay Automatic Telephone System (*Illus.*)	422
Riachuelo Transporter Bridge, Buenos Aires (*Illus.*)	424
The Institute of Metals	426
Textile Machinery and Accessories Exhibition at Manchester (*Illus.*)	427
Notes from South Yorkshire	430
Notes from Cleveland and the Northern Counties	430
Notes from the North	431
Notes from the South-West	431
Notices of Meetings	431
"Efficient and Economical Working and Management"	433
Working Hours and Output	434
Rubber as Applied to Aircraft	434
The All-British Wireless Exhibition	435
Notes	436
The Late Professor Herman-Victor Hubert	436
Industrial Notes	437
Letters to the Editor.—"The Strength of Railway Bridges." "States and Entities: What is Energy?" "Scientific and Industrial Research." "Sixth Report to the Corrosion Research Committee, Institute of Metals." "Double-Reduction Gears for Turbines." "Evaporation and Distillation." "Economy in the Use of Machine Tools." The Non-Radiating Atoms	437
Diagrams of Three Months' Fluctuations in the Prices of Metals	439
Extension Spindle for Internal Grinders (*Illus.*)	440
White Metals (*Illus.*)	441
Moulding Sands (*Illus.*)	443

Two-Page Plate.—INTAKE WORKS OF THE LITTLETON RESERVOIR.

ENGINEERING.

FRIDAY, OCTOBER 6, 1922.

"EFFICIENT AND ECONOMICAL WORKING AND MANAGEMENT."

EXCEPT for some few who work for work's sake, it is recognised that mankind labours of necessity; and it is accepted that on the whole it is well so, and that to supply our bodily needs considerable and sustained effort is not only requisite but salutary. It is the keen races who have been hard put to it to wrest a living from the earth in the less kindly areas, who have triumphed greatly over circumstance, while peoples whose lives are cast in the pleasant places where nature renders a profuse return, have sunk in ease to insignificance. Needs must that we work, and that being so, most have ever endeavoured that their toil should result in improving upon a bare subsistence allowance. To this end were directed the homely industry of the goodwife of Proverbs, and the effective management of flocks by Jacob, the greater ventures of the fleets of Hiram and the ships of Tarshish, and the trafficking of the merchants at the fairs of Tyre. The mainspring in all was that the effort expended should result in profit, or to make it possible to benefit as a result of such profit.

Without profit we, at the best, maintain a precarious existence. If we just pay our way and no more, chance winds blowing from any quarter of the globe may render life impossible. It is as essential that the community as well as the individual should have some reserve—a fact too often lost sight of by those who claim that the State should find employment for every man. However expedient or politic relief of unemployment by artificial schemes may be, in the end we become insolvent, if in the National Budget we cannot balance our account. It may not be essential in every instance and at all times to show profit on each of the various sections of our business life. Indeed, the early years of many flourishing industries have shown losses, and in some cases have only arrived at their present status by means of extraneous support. Or, again, a branch may be run as a permanent expense because of some reflex advantage it brings to the whole. Nevertheless the community cannot indefinitely carry a loss with it, considering affairs as a whole and over a period of time. It is generally accepted that the nearer each contributory effort comes to being not only self-supporting, but profit-earning, the better it is for all.

The words "profit earning" immediately suggest to most of us efficient and economical working and management. In a few occasional instances it is true that profit is possible now and then without either efficient working or sound management, but on the whole the margin is sufficiently fine for both to be essential, and so well is this accepted in theory that, whatever may be the result of individual interpretation, or—as often happens—misinterpretation of the principle, commercial efforts are commonly understood to be governed by the hope of attaining profit by efficient methods, without specific reference to the fact. Of course the Government is not a commercial concern. That has been proved conclusively in innumerable instances in recent years, and it is all the more curious that this Government, whose methods no private business could afford to copy, should have deliberately inserted in the Railways Act of 1921 a proviso embodying the words forming the title of this article. Under this Act, rates, as is now well known, are to be adjusted so that with "efficient and economical working and management" a definite profit may result.

The great railway transport industry of the country has commonly been regarded as well managed. But with the incentive of showing a profit removed by a form of guarantee, there are certainly good grounds for the Government thinking, with the example of so many State enterprises before them, that the efficiency of management might decline. The safeguard is therefore not unwise, if we can secure competent judgment as to what in particular instances may justly be taken to constitute economical working and efficient management.

To these questions of working and management Sir Sam Fay devoted his attention in his presidential address to the Institute of Transport on Monday last. The matter is necessarily bound up with the organisation which the new grouping will evolve. Sir Sam Fay stated that an organisation clothed with authority to deal with problems as they arose, was essential, and outlined the system to which we have before now made reference, of a central headquarters governing broad policies, and decentralised executive in close touch with the areas served. This, of course, is the key to military organisation, and, in the railway world, it has proved a success on the large systems of North America. Sir Sam Fay quoted the Canadian Pacific, but many of the other great lines are similarly organised. It is the only method which recognises the fact that human capacity has its limitations, and that if the big mind is to guide a huge undertaking, it must not be over-burdened with the lesser details. Having been chosen wisely and well, the superintendents of divisions, or whatever we may like to call them, can be left, as Sir Sam Fay says, a wide discretion, with encouragement to develop their areas. One of the secrets of success in large affairs where the limits of human capacity are approached, or reached, lies, of course, in the choice of men and in allowing them responsibility and scope within the widest limits possible. In this way live management can be developed, and advantage taken of managers with "positive minds," to use Sir Sam Fay's expression, while nothing has a more deadening influence than the knowledge that everything has to be referred to headquarters for decision.

It is worth pointing out that though, on the one hand, the Railways Act insists on efficient and economical working and management, it also gives power to the Railway and Canal Commission to order a railway company to improve its facilities even to the extent of costly capital works. It is to be presumed that there is intended to be some relation between such orders and the working of the rating body on which the guaranteed returns will depend. Clearly cases might easily arise, unless the situation be very carefully handled, in which orders for improved facilities for the benefit of traders would conflict with what the company or authority held to be consistent with efficient and economical working and management. The Act recognises this with regard to expenditure of capital, but it is not so clear what is to be done

when it is a question of services involving mainly operating expenses. We presume that in such an event the promised return to the company would in some way be safeguarded.

It will be remembered that when the Act was brought in, the Government's original scheme of workingmen directors was dropped by the mutual consent of the companies and the men, and the scheme of central and national wages boards adopted. We see now that the demand for seats on the boards of directors is being revived by a section of the National Union of Railwaymen, but we trust that this body as a whole will not endorse any demands or movement which will tend to upset the present system before it has been fairly tested. At the present time the railways have enough on their hands without being involved in further complications and require to be relieved of additional distractions.

WORKING HOURS AND OUTPUT.

Seldom, we imagine, has the danger which may lie in the acceptance and application of a crude generalisation been more clearly illustrated than in the conditions which have followed the general reduction in the length of the working hours in this country. All the ills we are now troubled with are not to be explained merely by the reduction in the working day, but this factor has an important bearing, and in view of the greater output in a shorter time which was promised us, compared with the results we have got, it is to be hoped that those who preached the blessings of a shorter day will note the conditions which have followed the application of their doctrines on a large scale. There were not lacking observers at any time who realised that conclusions drawn from a few specialised plants under special conditions could not properly be applied to industry at large, and it is to be hoped that some of the amateur industrialists who used to preach to us under the ægis of the Ministry of Munitions will by now have come to the same conclusion.

The present state of trade in this country has been brought about by many things, some of which are quite outside our control. Others, however, are of our own fostering, and even now much could be done to improve our condition in a comparatively short time if everyone concerned could be brought to a common mind and a common will. Transcending such matters as external debt and the state of foreign exchanges, our great present handicap is our decrease in productivity, and we cannot win back even to a pre-war position until we do more work. It is certainly matter for much satisfaction that in a general way we now appear to be doing better than we have done in the last few years. We have learned something in a bitter school, but we have yet far to go before we approximate to the happy conditions envisaged in the delirious months which followed the Armistice.

Our decrease in productivity and its general results have been only too evident, but as specific information is likely to carry more conviction to the mass than the most sober generalisations, much may be hoped from the valuable report which has been prepared by the Joint Investigation Committee which was appointed by the Engineering and National Employers' Federation, the Shipbuilding Employers' Federation and the Unions' Negotiating Committee. This Committee followed the general introduction of the 47-hour week in shipbuilding and engineering establishments, and was appointed to "investigate the economic relation of production to hours of work . . . and the methods of manufacture in the shipbuilding and engineering industries in this and other countries." The Committee came into existence in March, 1920, but its work since that time has been much interfered with by labour troubles which have demanded the attention of various of its individual members. A *questionnaire* was issued to a number of representative firms, while, in addition, a number of firms in the North were visited in June and July, 1920. In April and May, 1921, firms were visited in Belgium, Holland and Germany, while in August, 1921, further visits were made to British firms, mostly in the Midlands. The Committee recognised that to complete their work a visit should be paid to the United States, but this has not yet been possible.

In view of the fact that the Committee was representative of both employers and employed, it was felt that no statement of views, or deductions, from the data collected could be acceptable to the whole of the members, and as the data were too voluminous to be presented as they stood, it was decided to present a digest of the facts tabulated as far as possible, but without comment. This system has resulted in a report of moderate bulk, which might profitably be read by all who are concerned with British industry. Naturally, ancillary and incidental matters are touched on in the report, but its great feature of importance is the light it throws on the questions of productivity in its relation to hours of work and systems of payment.

Referring in the first case to the specific question of the output in the 47-hour week as compared with the 53-hour week, we find, in connection with the visits to British works during the summer of 1920, that definite reference is made to this matter in the case of 21 of the firms. In not one of these was it stated that the decrease in hours had resulted in no decrease in output. The most favourable report from this point of view was in the case of Firm No. 5, the manager of which stated his opinion that the men, if they liked, could turn out as much in 47 hours as in 52. This is not very satisfactory ammunition for the short-week enthusiasts, but it is the best that this group of firms furnished. In the case of nine of the firms it was definitely stated that the reduction in output was equal to, or greater than, the reduction in hours. Many of the others implied the same thing without stating it, and, for instance, in the case of Firm No. 15 it was found that the same men in the foundry took 50 per cent. to 100 per cent. longer to do identical jobs than they took in 1913, and machinery work took 25 per cent. longer, although facilities were better. It should, perhaps, be said that the 21 firms with which we are now concerned are among the first in the country and that there is no question of inefficient management. Practically every firm will be known to our readers, and while it is not necessary to reproduce the list, we may point out that the first three in alphabetical order are Armstrong, Whitworth, Sir Wm. Arrol and Babcock and Wilcox.

In considering these results it is necessary to remember that these investigations took place in the middle of 1920, when the unsettlement of individuals occasioned by the war had, perhaps, still considerable bearing on performance. If, however, it is argued from this that the lapse of time would enable the advantages of the short day to display themselves, the point of view receives little confirmation from the second series of visits to British works, which was made more than a year later—in August, 1921. Of 12 firms reporting in connection with this point, no less than nine state that output had decreased in proportion to decrease in working hours. These firms are of equal standing to those we have already referred to. One firm of the 12 reported that in the meter department the same output was obtained in 47 hours as previously in 52½. In this case all employees were on piece-work. Much the same reduction in output, following reduction in hours, was found in connection with the Continental firms which were visited. Thus the Mercantile and Marine Engineering Company, of Antwerp, reported a reduction of efficiency as compared with the pre-war level; the Société Anon. Ougree Marihaye, of Liége, found the reduction in output equivalent to the reduction in hours; Alfred H. Schutte Works, of Cologne-Deutz, reported the same thing, as did the Nederlandsche Scheepsbouw Mij, of Amsterdam. On the whole, however, judging by the number of firms referring to the matter, the effect is less marked on the Continent than in this country.

In connection with the British firm which reported an equal output in 47 hours and 52½ hours, it was stated that all the workpeople were on piece-work. This is an important aspect of the whole question, and we think that in all cases in the report where the subject is discussed it is stated that payment by results was remarkably superior from the production point of view to payment by time. The most striking figures of this kind were furnished by shipbuilding firms in reply to the *questionnaire* of the Committee. For instance, mechanics fitting watertight sliding shutters took for the same job 490 hours on time-work and 150 on payment by result; on frame setting, 14 weeks were required for 54 pairs of frames on time-work and 5½ weeks for 80 pairs of frames on payment by results; and while two 12-in. ventilator cowls were made in 14¾ hours on payment by results, 30 hours were required on time-work. Very many comparative sets of figures of this kind are quoted in the report, and there is nothing on the other side to offset them. In view of the invariably better results obtained by some form of payment by results, it is of interest to note that of the 18 Continental firms of which details are given, in 11 the majority of the employees are either on piece-work or under some kind of bonus system. No details of the remaining seven are given.

The moral of this report is fairly clear. Although during the war reduction of excessive hours in certain repetition factories may have been made without loss of output, experience has shown that to assume from this that the reduction of normal hours in ordinary industry will be attended with the same results is unsound. At a time when maximum production was vital we introduced conditions which made it difficult or impossible. The practical steps which should be taken now are obvious. Although with much unemployment and weakened unions the reintroduction of the 53-hour week would probably not prove impossible, none the less such a step would be very unpopular with a very large body of men and would lead to much ill-feeling. The procedure is probably hardly necessary. What is required, however, is a considerable extension of some form of payment by results, so that adequate work may be obtained during the shorter day. We gladly recognise that the skilled engineering unions have shown less hostility to such methods of working than many others, but in numerous cases their help has been nullified by the action of other unions. The present line of progress lies in the far greater extension of piece or bonus systems in the foundry and among woodworkers, and it is to be hoped that employers will press for this and that the unions concerned will become acquainted with the report we have been considering and will modify some of their ideas.

RUBBER AS APPLIED TO AIRCRAFT.

The standpoint from which Mr. J. W. W. Dyer, M.Sc., A.I.C., of Gravesend, late of the Air Ministry, approached the problems of "Rubber as Applied to Aircraft" in a lecture delivered before the Institution of Rubber Industry last Monday, was that of the chemical engineer who has to test the varied rubber appliances, to examine the methods used, *e.g.*, in the manufacture of gas bags, and to study the suitability of the materials and their possible substitution, with special regard to the severe conditions the appliances have to meet on aircraft. If the war was instructive, because risks had to be taken as to machines and materials, it was unfavourable to systematic testing, endurance testing, for instance, which demand time and control of many factors. Thus many problems remain unsolved.

Dealing first with appliances such as shock absorbers and petrol hose for craft heavier than air, Mr. Dyer pointed out that the advantage of rubber over springs, etc., was its high capacity for absorbing energy. There had been few complaints about the rubber cords. He had found some external individual threads faintly spotted and distinctly oxidised in a piece of cord that had been sent back from somewhere in the East; the effects were probably due to the tropical heat and the sun's rays, the light gaining access through the interspaces in the braiding, and it was noteworthy in that connection that actinic tests were not customary. The petrol hose were tested, while being vibrated, for permeability, mechanical strength and adhesion of rubber to canvas; the internal dope proofing, put on the rubber, was apt to crack and to become brittle, the seams tended to unlap, and the joints of the sections in particular might give trouble. Inner linings consisting merely of animal membranes were found to give satisfaction, but it was considered that metal pipes might answer

better than rubber hose, provided they were able to withstand the vibrations.

As regards the envelopes and ballonets of kite-balloons and airships, no rival for rubber seems yet to be in prospect. The envelope consists of two- or three-ply cotton fabric with several layers of rubber, protected on the outside against the sun rays by an aluminium coat. Materials of low specific gravity are alone admissible, since large areas are involved; the maximum weight which Mr. Dyer mentioned for the gas-holding layer of rubber was 100 grammes per square metre; a rubber of more than 95 per cent. was used, the permeability to hydrogen of which increased by 5 per cent. per deg. C., but 10 per cent. of litharge—even 20 per cent. in outer layers—might be mixed with the rubber in addition to sulphur. The vulcanisation might lower the permeability, probably owing to the formation of lead sulphide, though there was no recognised standard of vulcanisation, and the permeability of litharge-rubber certainly increased under tension; but there was unfortunately hardly any method of mechanically testing rubber when applied to fabric. The "molecular protection" imparted to rubber by certain dyes was, however, successful; the anti-actinic aluminium finishing, containing 12 grammes of aluminium and less per square metre, likewise protected the rubber. But the protection of the cotton fabric was equally important.

Great care was taken to render the fabric faintly alkaline; but there was some acidity due to the oxidation of the sulphur in the rubber, which Mr. Dyer said, tended to disappear on exposure—a rather surprising statement. Mr. Dyer, however, thought that on the whole acidity had little to do with the destruction of the fabric; but we should make really sure that tension did not materially affect these factors, as was too readily assumed. On the other hand, Mr. Dyer was able to state that the tests, including exposure tests in Egypt, of nearly fifty balloon fabrics of British manufacture had disproved the gloomy forebodings of those who predicted that no rubbered fabrics would last a month in Egypt. Some fabrics of Italian make did not prove superior to the English goods.

Mr. Dyer gave particulars about the main use of rubber in rigid airship work, for the manufacture of the gas bags. There the rubber serves merely as an adhesive, the gas-holding element in the fabric being goldbeater's skin, which is stuck to the inside of a light cotton or silk fabric. Two layers are used, and the finished fabric should not weigh more than 160 grammes per square metre. The goldbeater's skins are supplied in sheets of foolscap paper size, which, in the British practice, used to be seamed together with rubber in 5 per cent. glycerin solutions to build up the 25,000 or more square metres of the gas bags wanted for a large rigid airship.

Serious troubles, however, were found to develop with these bags; matters improved afterwards, but pockling of the fabric, *i.e.*, creasing and separation of the parts, was still observed with "shade-temperature" tests made in Egypt, though the materials were not directly exposed in these tests to rain and sunshine. Now the combination of rubber and goldbeater's skin is undesirable, because the skin contracts as it dries and expands on moistening, while rubber does the opposite. The Germans used a kind of glue which Mr. Dyer found decidedly preferable to rubber in these respects and also because of its greater adhesive power. Attempts were made to improve the rubber method, and an adhesive layer of rubber was introduced which was self-vulcanisable in tropical heat. Mr. Dyer was not convinced that the degree of success then obtained was due to self-vulcanisable layer, but he would not say that rubber might not answer. Among the various advantages of rubber was freedom from mould attack.

But there was the wider question whether a substitute could not be found for the goldbeater's skin. If rubber-proofed material became at 40 deg. C. equally permeable to air and to hydrogen, as was believed, whilst it was at ordinary temperature only one-quarter or one-fifth as permeable to air as to hydrogen, that would be a serious objection to such materials. But rubber might yet be manufactured in ways to do its best. Rubber-proofed outer covers, weather- and light-proof, laced to the metal structure and completely enclosing the gas bags but separated from them by an air space, might give satisfaction. The present practice of applying a dope *in situ* in order to produce the required tautness by contraction on drying seemed to rule out rubber. Doping *in situ* is expensive, however, and tautening might be effected mechanically while an already proofed material was being put on. The various suggestions made by Mr. Dyer called forth constructive criticisms by Dr. Schidrowitz, Dr. H. P. Stevens, Mr. B. D. Porritt and other well-known experts. Colonel Bristow was in the chair.

THE ALL-BRITISH WIRELESS EXHIBITION.

The development which has taken place in the manufacture of wireless apparatus for amateur use since the Postmaster-General agreed to permit the regular broadcasting of music and other matter of general public interest by wireless telephony, is demonstrated to a remarkable extent by the exhibition now open at the Horticultural Hall, Westminster. A couple of years ago the needs of the few amateurs then interested in the subject were supplied by some half a dozen firms, whereas the apparatus shown at the Horticultural Hall has been produced by over 50 different concerns. Moreover, the exhibits have been confined entirely to goods of British manufacture, and as this stage has been reached before the regular broadcasting has actually commenced, it is not unreasonable to suppose that the industry will grow to important dimensions during the next few years. The Postmaster-General's recent recommendation that, for a certain period, the manufacture and sale of wireless apparatus in this country should be confined to British firms, will also doubtless enable the industry to establish itself sufficiently to meet foreign competition in the future.

The particular device which has rendered practicable the transmission and reception of telephony over long distances is, of course, the three-electrode, thermionic valve, but as this device was developed mainly during the war, when secrecy was essential, even the technical and scientific public is less acquainted with its properties and characteristics than would normally have been the case; at this stage, however, we must assume that its properties are understood. Comparatively recently developments in valve design and construction have rendered it possible to greatly increase the power for transmitting telegraphy by continuous waves, and the Marconi station at Carnarvon, we believe, is now capable of employing 500 kw. by using a large number of valves in parallel. What is claimed to be the largest single-unit transmitting valve made is shown at the exhibition by the Mullard Radio Valve Company, Limited, of Hammersmith. This valve, which is of the three-electrode type, is capable of dealing with an input of 4 kw., but we were informed that similar valves have been made experimentally for inputs up to 10 kw. The bulbs of these valves and of a 4-kw. rectifying valve and a 1-kw. transmitting valve, also shown by the firm, are constructed of fused silica instead of glass. The M.O. Valve Company, Limited, of Brook Green, Hammersmith, also showed a comprehensive series of valves of all types ranging from the well-known V.24 type receiving valve to high-power transmitting valves. The series includes a number of low-temperature valves which work satisfactorily with filament voltages as low as 1·8, and can be operated by primary batteries. A Marconi 3-kw. continuous-wave transmitting set for telegraphy or telephony is also shown at this stand.

Receiving sets in great variety are shown by the majority of the exhibitors, and their number is such that it is impossible to refer to them individually. Prospective users can select, according to their requirements and resources, from a range which commences with simple and roughly-made crystal detector sets that can be carried in the pocket, and concludes with elaborate multi-valve sets mounted in cabinets which constitute attractive articles of furniture. Some sets of the latter type are certainly fine examples of the craft of both instrument makers and cabinet makers. The crystal detector sets would, in general, be sufficiently sensitive to receive the broadcast telephony at distances up to about 20 miles or so from the transmitting stations. It is understood that eight of the latter will eventually be installed, and as they will be situated in or near populous centres there appears to be a good market for the simple and inexpensive crystal sets. Among the valve sets shown we may mention one made by the British Thomson-Houston Company, Limited, Rugby, which combines efficiency with portability. This is a two-valve set employing one rectifying and one low-frequency amplifying valve in conjunction with a hinged frame aerial. The whole of the equipment, including the accumulator, is contained in a polished wood box about the size of an attaché case and weighing under 20 lb. The frame aerial, of course, has important advantages in the matter of selectivity.

In most cases fixed inductances are employed with variable air condensers for tuning, but variometer tuning, in which the mutual inductance of a pair of coils connected in series is varied by moving one coil relatively to the other, appears to be gaining ground. A neat design of variometer in which elliptically-shaped coils are mounted on the inner and outer surfaces of two concentric ebonite cylinders is shown by Messrs. Anode, Limited, 265, Strand, W.C. 2. Tuning is effected by turning the inner cylinder about its axis through a complete revolution, and with two such variometers, a wave-length range from 150 m. to 10,000 m. can be obtained. The same firm show a new design of tuning condenser in which the capacity is varied by adjusting the distance between two sheets of copper foil mounted on ebonite, a fine-threaded screw being used for the purpose. Contact between the foils is prevented by a thin sheet of mica. Condensers of all types and sizes are shown by the Dubilier Condenser Company (1921), Limited, of Shepherd's Bush, W. 12, and their exhibit includes an interesting and novel device which enables the wiring system of any electric-light installation to be used as an aerial for wireless reception. It comprises two fixed condensers enclosed in an insulated box which is provided with the usual bayonet connection at one end for attachment to an ordinary lampholder. Two terminals are provided at the other end of the box, and connection from one, or both, of these is made to the aerial terminal of the receiving apparatus. When so arranged, the two condensers are in series with each side of the mains, so that while direct current, or low-frequency alternating currents, are kept back, the high-frequency oscillations induced in the mains by wireless signals can pass freely.

Several firms show head-band telephones and loud-speakers, but from an engineering point of view the most interesting exhibit of this class of apparatus was that of Messrs. S. G. Brown, Limited, of North Acton, W. 3. In addition to displaying a full range of their well-known products, Messrs. Brown demonstrated the method of manufacturing the conical aluminium diaphragms which form an essential feature of their telephones. In these, the sound vibrations are produced in a stiff steel reed in the form of a cantilever, the end of which is connected to the centre of the aluminium diaphragm. The latter is supported at its periphery by an inwardly-flanged ring pressed from a sheet of aluminium and forming, with the diaphragm, a cover which completely encloses the internal parts. In making the diaphragm, the ring is placed in a collet chuck of a precision capstan lathe and a bead formed on the flange by a suitably-shaped tool. The diaphragm, in the form of a flat disc 0·002 in. thick, is placed in position, and the bead turned over by another tool so that it grips the disc round its edge. The central portion of the disc is then spun inwards to a conical form, and a groove is also formed near the edge of the diaphragm to localise the minute bending which occurs when the diaphragm vibrates. Engineers would also be interested in the machine for winding duo-lateral or honeycomb inductance coils shown in operation at the stand of the Igranic Electric Company, Limited, 147, Queen Victoria-street, E.C. In these coils, which are made under the De Forest patent, the maximum spacing between the various turns is obtained, thus reducing the self-capacity to a minimum. Two machines for winding the coils of

inter-valve transformers were also shown in operation by this firm.

Amateur transmitting apparatus is not much in evidence, but the Marconi Company include in their extensive exhibit of receiving apparatus, a small low-power transmitting set intended to be used by large retailers for the purpose of demonstrating the efficiency of receiving apparatus at any time. The set includes a gramophone and valve transmitter of just sufficient power to transmit music produced by the former from one room to another in the same building. The Marconi Company also show a collection of exhibits of great historical interest and in marked contrast with the modern apparatus on the same stand. Among these exhibits is the 18-in. spark coil used at the Needles Station, Isle of White, in 1898, a coherer of the standard type used from 1899 until about 1908, an early magnetic detector, and one of the first Fleming valves used as far back as 1904.

The exhibition, which closes to-morrow, has certainly been a success from the point of view of attendance. The programme included a series of popular lectures on wireless subjects arranged by the Wireless Society of London, in addition to which a considerable section of the public must have been made acquainted with the possibilities of broadcasting by the transmissions of speech and music from Marconi House at intervals during the day. In conclusion we would remark that the organisers of the exhibition, Messrs. Bertram Day and Co., Limited, as well as the exhibitors, are to be congratulated on their efforts which can hardly fail to be of material assistance in developing the industry still further.

NOTES.

The Railways of the United Kingdom in 1921.

The official returns just published relating to the working of the railways of the United Kingdom in 1921, are of little value except as far as they illustrate the disastrous results of long-continued industrial restlessness and abnormally high prices. The year was distinguished for the coal strike which dragged over weary months, while prices were so advanced as to curtail purchasing power, with the inevitable result that traffic declined in freight and passengers movement was reduced to far below what the community would wish to enjoy. The gross receipts of the companies were 246,051,000*l.*, while the gross expenditure amounted to 256,385,000*l.* The former shows a decrease of over ten millions sterling, and the latter an increase approaching six millions, so that the position was much less satisfactory than in the previous year. The Government compensation paid amounted to 53,211,000*l.* Goods traffic showed the enormous decrease of 100,000,000 tons—nearly a third of the previous year's traffic. The largest decrease was, of course, in coal and coke, and amounted to a falling-off of about 53,500,000 tons, while other minerals showed a decrease of 29,000,000 tons, and general merchandise a fall of 19,000,000 tons. The same lamentable tale is told by the passenger traffic statistics, which in the case of ordinary passengers showed a decrease of about 200,000,000 as compared with 1920, while the journeys represented by season tickets revealed a decrease of over 400,000,000. The first-class traffic showed a very large reduction, namely, 32·88 per cent. in ordinary first-class passengers and 17·17 per cent. in first-class season ticket holders. This would appear to point to the fact that the serious conditions of the coal strike and trade depression brought back to their normal class a large number of people who had previously been enjoying an evanescent prosperity which they deluded themselves into believing a permanent feature of post-war conditions.

The Electric Power Supply to the South Eastern Railway.

There can be no question but that the Electricity Commissioners have acted correctly in refusing permission for the South Eastern and Chatham Railway Company to build a special electric generating station to supply power to their suburban lines which are to be equipped for electric working. The essential business of the Electricity Commissioners is to bring some kind of unification into the electric supply business of the country and it is clearly their ordinary duty to refuse to have the situation in London further complicated by the introduction of another station having no relation to any general scheme of supply. The railway company wished to build a station for their own purposes at Angerstein's Wharf, Charlton, but at the public inquiry held in May last it was pointed out by the Commissioners that the plans for this station which were put in were such that they were impracticable for a station of an ultimate size of 150,000 kw. This was admitted by the principal technical witness for the railway company, who agreed that a complete modification of design would be necessary. Apart from this, however, the Commissioners are doubtful if a 150,000-kw. station could be built on the site at all. Offers to supply power to the railway had been made at that time by the West Kent Electric Company and the County of London Electric Supply Company. These companies have since renewed their offers on more favourable terms, and a further offer has been made by the London Electric Supply Corporation. It appears to be admitted that these offers are such that the railway would obtain its current as cheaply, if not more cheaply, than it could generate it itself. The reason for the railway company rejecting any of these offers, unless it be a tendency to perpetuate the parochial spirit, can only be that it is not satisfied about the guarantees. As, however, two of the offers are supported by one of the leading banks it is difficult to see that this can be the reason. If the matter is a question of continuity of supply we think the Directors of the South Eastern Railway can take it that the County of London Electric Supply Company is quite as capable of keeping a generating station in operation as they are. However, as the permission to erect their own station has been refused to the railway company, one may presume that one of the three offers will now be accepted, and in the long run we have no doubt but that the South Eastern Railway will find, as the Brighton and North Eastern Railways have already done, that the purchase of electrical energy from outside is an entirely satisfactory proceeding.

Trials of a Doxford Motor Ship.

On Thursday, September 28, the motor ship Eknaren left North Shields for a short demonstration trip, having on board a representative party of shipowners and marine engineers as guests of Messrs. William Doxford and Sons, Limited, of Sunderland, the builders of the vessel. The Eknaren is a motor ship 420 ft. long by 54 ft. beam with a deadweight capacity of 9,300 tons on a draught of 26 ft. She has been built to the order of the Swedish Transatlantic Company of Gothenburg, and is a sister ship to the Yngaren of the same company and to the Dominion Miller owned by Messrs. Furness, Withy and Co. All three vessels were constructed and engined by Messrs. Doxford, the engine in each case being a four-cylinder two-cycle Doxford opposed-piston engine indicating 3,000 i.h.p. at 77 r.p.m. We described this type of engine at some length in our issue of December 24, 1920, in connection with the shop tests of the Yngaren engine, and shall reserve further particulars of its construction until we can illustrate it fully, which we hope to do in the near future. Meanwhile we may say that it showed itself extraordinarily handy in operation at sea and could be slowed down to about 18 r.p.m. without stopping. It was quite silent and free from vibration at all speeds, and could be manœuvred as easily as a steam engine of corresponding size. At the lunch which took place on board Mr. Robert Traill, of the Fairfield Shipbuilding and Engineering Company, stated that the Doxford engine was no longer an untried novelty, as the behaviour of the Yngaren and Dominion Miller had shown that in many respects it was in advance of any other type. The cylinder covers, which had been such a bug-bear in connection with some other Diesel engines, had been eliminated altogether, and the adoption of the solid injection principle had done away with the high-pressure air compressor for injecting fuel. The opposed pistons also resulted in a perfectly balanced engine, and in no steam engine room could one talk so comfortably and peaceably. There was no reason why the crankshaft should give any more trouble than the ordinary built-up shaft of a steam engine, which was severely criticised by marine engineers when it was first adopted. With regard to the behaviour of the Yngaren's engines, Mr. Traill remarked that no steam engine ever put to sea was manœuvred with greater ease. The governor acted instantly and checked racing, although the vessel was travelling so lightly loaded that the propeller was half out of the water. The advantages of oil-engines on board ship were so great that no shipowner could afford to ignore them, and they were bound to find their place in passenger vessels. His own firm had indeed just booked an order for a 600 ft. passenger vessel to be driven by oil engines at a speed of 18 knots. It would have 12,000 h.p. on four shafts, and would make an 18 day trip from Australia to Vancouver. The adoption of oil engines had enabled both passenger and cargo capacity to be considerably increased, and the benefits were so great that the slightly greater cost of the Diesel engines was a matter of no moment. The Yngaren was running with 9 tons of oil per day for her main engine and half a ton for all other purposes. With 9½ tons per day, she maintained a speed of 10·6 knots, and had just left an American port loaded with cargo to 6 in. beyond the water line. She was a vessel of 9,300 tons d.w. capacity and with oil at 29*s.* per ton, was operated at a cost of less than 15*l.* per day for fuel. Mr. Robert Doxford, in replying for the builders of the ship, said that in America the Sun Shipbuilding Company were now building, under licence from his firm, two Doxford opposed-piston engines, exactly similar to that on the Eknaren, and he hoped to see similar enterprise nearer home.

THE LATE PROFESSOR HERMAN-VICTOR HUBERT.

We greatly regret to have to record the death, which occurred at Spa, on September 30, of Professor Herman-Victor Hubert, of Liége University.

Professor Hubert was born in Liége on May 19, 1849, and quite early in life he was noted for his great love of work and his keenness in the acquirement of knowledge. The success which attended his studies, notably at the Liége University where he qualified as an engineer, whilst he followed courses in philosophy and literature, attracted the kindly notice of his various professors. It should be noted in this connection that he lost his father when he was only nineteen years of age, the responsibilities for the family thus devolving upon him at a time when he was preparing actively for his profession. Nevertheless, he sustained brilliantly the examination for the diploma of mining engineer, and was appointed to the Corps of Mining Engineers at Mons, when he was barely 23. At the same time as he carried out the important duties of a mining engineer in the Mons district, his activity was such that he undertook a professorship of differential and integral calculus, and of physics both pure and applied.

His work as a mining engineer having led to his transference to Liége, he obtained the post of professor of geometry and mechanics at the college of that city; he ultimately became the director of the college, and soon after was appointed assistant professor of applied mechanics to the late Mr. Dwelshauvers, at Liége University. The numerous engineers who have studied under Professor Hubert remember him as a most clear exponent of all technical problems; besides this, his unvarying courtesy endeared him to them all.

Professor Hubert was promoted to Chief Engineer of Mines in 1898, and the reputation he had acquired as an expert in mining matters led to his being appointed on various prospecting expeditions in the Crimea, Spain, Sardinia, Algeria, Hungary, Holland, the Caucasus and America. When, in 1904, Mr. Dwelshauvers was created Emeritus Professor of Liége University, Professor Hubert succeeded him, and the manner in which his nomination was received by his pupils, former pupils and friends afforded a striking proof of the esteem in which he was held.

He contributed extensively to the "*Annuaire de l'Association des Ingénieurs de l'Ecole de Liége*," notably in the matter of high power gas engines, a type of engine for which, from the very commencement, he entertained the greatest hopes. During the late war, Professor Hubert resided many months in London, where he made a large number of friends. It will be remembered that at the spring meeting, 1915, of the Iron and Steel Institute, he read a paper on "Blast-Furnace Gas Engines with Special Reference to Belgium."* Our last reference to Professor Hubert is given on page 807 of our last volume, this being

* See Engineering, vol. xcix, pp. 562, 662, 688.

our report of the Congress held in Liége in June, on the occasion of the seventy-fifth anniversary of the formation of the Liége Association of Engineers, when he opened the proceedings and welcomed the visitors, among whom were the president and many members of the Institution of Mechanical Engineers.

At the time of his death, Professor Hubert was Hon. General Inspector of Mines and Emeritus Professor at Liége University. He was also intimately connected with a number of Belgian industrial concerns; he was a member of the Institution of Mechanical Engineers since 1915, a member of the Iron and Steel Institute since 1906, also a member of French and American scientific associations. He was, further, a Commander of the Order of Leopold, Grand Officer of the Order of the Crown, Commander of the Order of the British Empire and Officer of the Legion of Honour.

He leaves a widow and a young son to whom we tender our deepest sympathy. We desire to condole also with the host of Belgian colleagues who will greatly miss their genial professor and friend.

INDUSTRIAL NOTES.

THE Southern Federation of the National Union of Railwaymen Districts Councils claim that the time has now arrived when the workers should have a voice in the management and control of the railways, so that they may give expression to their views on the working and the development of the railways. It is stated that many instances of waste and inefficiency could be pointed out, but that at the present moment workers are afraid of jeopardising their position by interfering. The latter part of this statement is probably an exaggeration, but the above claim may be welcomed by some if it indicates the abandonment of railway nationalisation schemes. Sir Sam Fay, the general manager of the Great Central Railway, in the course of his presidential address at the third annual meeting of the Institute of Transport, said, on this latter subject, "that from time to time the fingers of bureaucrats had itched to catch hold of railway management and remodel it on a Whitehall pattern, but public opinion, in the light of war experience, had evinced a very decided dislike to experiment in the direction of Government ownership of industry. Thus the railways had emerged from the war's turmoil still under private ownership, but coupled with a large measure of State control."

Since our note on page 373 *ante* was written there have been several meetings to consider the tramway crisis. A provisional settlement was arrived at following a meeting held at the end of last week, and the tramwaymen are to ballot on the following terms: (1) The present rate of wages shall be maintained until the commencement of the first full-pay period in October, 1922. (2) On and from the commencement of the first full-pay period in October, 1922, deductions from, and additions to, wages shall be at the rate of 1*s.* per week for each complete four points variation either way in the cost of living index figure, all items included, published in the *Labour Gazette*, commencing from the figure of 135 per cent. over August, 1914, in respect of the maximum war wage increase of 40*s.* per week. (3) On and from the commencement of the first full-pay period in October, 1922, the present rates of wages shall be reduced by a sum of 4*s.* per week in accordance with the cost of living index figure at September 1, 1922, namely, 79 per cent. Then follow six other clauses stating that thereafter adjustments shall be regulated every three months, determining the length of the agreement, &c.

Mr. R. Coppock, the secretary of the National Federation of Building Trades Operatives, is reported to have stated that building contracts which had been held up since the war have been released to the amount of 15,000,000*l.*, a third of this relating to London alone. Unemployment in the building trade, he added, has now been reduced by 75 per cent., and business should be brisk for another five years.

The Mining Association of Great Britain have formally requested the secretary of the Railway Clearing House to arrange a meeting to discuss lower rail rates for coal traffic. The coal industry, with a loss of nearly 2,000,000*l.* in the fifteen months since Government control came to an end, has done everything in its power to restore itself to an economic basis. Miners' wages have declined to a point between 40 per cent. and 50 per cent. above the 1914 figure, while gross trading profits, even in July last, when America was buying large quantities of British coal, were less than ½*d.* per ton. The Mining Association are strongly of the opinion that present conditions do not warrant a railway charge of more than 50 per cent. above pre-war rates for coal traffic, and that nothing less than a reduction of rates to this point, plus the total abolition of the flat rate, can suffice to help the trade of the country to recover.

At a meeting held last Friday, the Cardiff Chamber of Commerce decided to support a resolution to be submitted to the quarterly meeting of the Association of British Chambers of Commerce in favour of reverting to an 8-hour day for miners. The resolution came from the Sheffield Chamber of Commerce, and read as follows: "Whereas the anticipations of the leaders of the miners, on behalf of the men, at the time of the Sankey Commission, as to maintaining the efficiency of production under a Seven-Hours Act has not been realised, and whereas an abundant production of cheaper fuel is essential to reduce unemployment and for the recovery of industrial prosperity, this association earnestly requests His Majesty's Government to introduce amending legislation to the Seven-Hours Act, which shall at least permit those coalowners and coal-miners who are in agreement to arrange for a working week of 8 hours per day."

A special conference of the South Wales Miners' Federation was held in Cardiff last Saturday, when it was decided by a large majority in favour of tendering 14 days' notice on the 23rd inst., with the object of forcing into the Federation miners who do not belong to it.

The dispute at Ebbw Vale remains so far open, and conferences have been held in order to clear up a number of points at issue. These have reference to the cancellation of allowance and tonnage rates, and to the drawing up of a new price list. At the demand of the men, the matter was referred to arbitration. The arbitrator, Dr. Galloway, issued his award on July 27, this containing a new price list to come in force as from November 1. The award was differently interpreted by the Ebbw Vale Company and the miners. At a meeting held in Cardiff last Monday, Dr. Galloway explained his ruling in the following terms: (1) He adhered to and reaffirmed his verbal interpretation made on August 9 last. (2) He decided that the three months interval expiring on November 1 next was intended to enable the parties, after mutual consultation, to arrive at an agreement as to what allowance, or what proportion of the allowances paid at present were to continue after November 1. (3) The question of allowances of all kinds was to be discussed between the parties from the point of view of affording workmen, where the circumstances justified, such allowances as would so far as possible place them in as good a position as to their earning power as their fellow-workmen in the surrounding districts, and so that such allowance should be in all respects subject to the usual practice of the South Wales coalfield. At the time of going to press the dispute remains unsettled. The decision of the Federation, stated above, in the matter of non-union miners may possibly influence an early solution of the difficulty.

The National Citizen's Union, "a non-party organisation having over 300 branches throughout the country," with offices at 56, Victoria-street, S.W. 1, has just issued a manifesto pointing out that the total gross expenditure estimated by Government for 1922–23 amounts to 948,113,000*l.*, against the total expended during 1913–14 of 207,817,347*l.* Comparative figures taken from the manifesto are as follow: Navy, Army and Air Force, 1913–14, 86,027,992*l.* (1922–23, 167,127,000*l.*); education, 19,169,647*l.* (as against 55,487,000*l.*); Labour, 1,161,712*l.* (as against 22,370,000*l.*). The union recommends, in regard to education, that expenditure be limited to a sound elementary education upon essential subjects, with provision for continued or higher education, or for vocational training, for such pupils only as show reasonable likelihood of being able to profit thereby. In the matter of labour, it asks for the drastic reduction of Labour Exchanges and of the Ministry of Labour. As for other services, it recommends the abolition of the Ministry of Transport and the discharge of necessary Road Department and Electricity Commissioners' duties under the Board of Trade. Abolition of the Mines Department and the transfer of any essential functions to another Government Department. It recommends further that the expenditure involved by the Great War be apportioned so as to fall upon future generations to a greater extent than is contemplated. The president of the union is the Right Hon. Lord Askwith, K.C.B., K.C.

In a review sent us by the Swedish Consulate General in London, it is stated that in the Swedish engineering trade the number of workmen employed reached low-water mark at the end of the first quarter of 1922, the total being only 25,200, compared to 60,000 in September, 1, 1920. At the end of the second quarter of the year some advance had taken place, as the figure stood at 26,400. This advance was mainly due to an increase of 6·5 per cent. in the number of employees in the general mechanical trades; in the electrical industry the rise was only 3 per cent., whilst the shipyards showed a slight decrease. Between 4,000 and 5,000 workmen were occupied with Russian orders for the construction of railway engines, but as this work was concentrated in a few large shops the general situation had not much improved thereby. Competition from Germany and other countries having a depreciated currency was still important, but late deliveries and export control often discouraged Swedish importers from placing orders with German and Austrian works.

"THE STRENGTH OF RAILWAY BRIDGES."

TO THE EDITOR OF ENGINEERING.

SIR,—In your last issue Mr. Gribble, writing of the method used by myself of arriving at stress in a riveted beam, refers to a similar method described in the latest edition of "Framed Structures," by Messrs. Johnson, Bryan and Turneaure. I presume he refers to Volume III, issued in 1916. I was not till now aware of this. The method occurred to me in 1904, or earlier, old calculations showing that I was applying it in that year.

A reference to the same procedure will be found in the ENGINEERING review of "Graphics and Structural Design" (Hess) appearing on May 11, 1917. I wonder it is not commonly used as being more correct, and simplifying computations.

Yours faithfully,
W. H. THORPE.

October 2, 1922.

"STATES AND ENTITIES: WHAT IS ENERGY?"

TO THE EDITOR OF ENGINEERING.

SIR,—The remarks of "A Reader since 1910" are helpful; but to act upon his proposal as to reserving "energy" for wider use in physics would be to encourage the *abuse* of the word, and so make confusion worse confounded. If "energy" means ability, or capacity or possibility, to do work, that is no reason for pretending that it has mass, inertia and structure. A body in motion is thereby in a state or condition to move other bodies with which it may come into contact, and so do work; and this ability to shift such other things we call energy.

Let us, by all means, "be precise in speaking of motion"—and of matter too. "Matter is always in motion"; I agree; but the statement, though true, is not precise enough. An engineer might say to a brother engineer that a locomotive going 60 miles an hour is in motion; but, when standing still at a railway-platform, this same engine is *not* in motion in relation to its surroundings; and even Einstein himself, when discussing what he calls "pseudo-problems," says "there exist merely bodies at rest and in motion relatively to one another."

A body lying on the ground anywhere near the equator is moving about 1,000 miles per hour relatively to the earth's axis which, relatively to the sun, is moving more than 1,000 miles per minute; yet the body which is idly resting around remains in one position in regard to other bodies "at rest" near by.

"In physics, energy is an entity; that is, it has real existence and may be discrete and discontinuous." Is not your learned correspondent mistaking "existence," *a state*, for an entity?

I have nowhere made the suggestion of "light, for example, having substantial character." Light is the *sensation* produced in us by a sense-stimulus due to spread of disturbance through a medium surrounding us, which medium, however attenuated, is still material—having mass, inertia and structure, though the latter may for ever be beyond our means of detection.

"CONSTANT READER" (since 1870).

September 30, 1922.

"SCIENTIFIC AND INDUSTRIAL RESEARCH."

TO THE EDITOR OF ENGINEERING.

SIR,—In your spirited criticism of the engineering programme of the Lubrication Research Committee of the Department of Scientific and Industrial Research (ENGINEERING, September 22, p. 369), I note that reference is made to a suggestion in the report that failure in the lubrication of high speed bearings of large dimensions might be due to turbulence in the oil film.

In deriding this suggestion as "mechanically inconceivable and mathematically impossible," though on what grounds is not stated, the article proceeds to characterise the suggestion as "one of Reynolds' mistakes."

Apart altogether from the merits of this criticism, into which I have no desire to enter, I submit that to classify the suggestion as "one of Reynolds' mistakes" is quite unjustifiable unless a definite and precise reference is given to where in his published work this statement can be found. I hope it may be possible to supply this in your next issue.

Yours faithfully,
T. E. STANTON.

The National Physical Laboratory,
Engineering Department, Teddington, Middlesex.
September 30, 1922.

[In the article on "Lubrication" in the 10th edition of the *Encyclopædia Britannica*, Osborne Reynolds wrote as follows: "This sudden change in the law of resistance to the flow of a fluid between solid boundaries, depending

as it does on a complete change in the manner of flow—from direct parallel flow to sinuous eddying motion—serves to determine analytically the circumstances as to the velocity and the thickness of the film under which any fluid having a particular coefficient of viscosity can act the part of a lubricant . . . when the circumstances are such that $U D \rho/\mu$ is greater than K . . . the fluid has no lubricating properties." This was understood to imply that turbulent flow might arise in the fluid between a journal and its brass, and that if it did so, seizing would occur. It is evident that the writer of the report of the Department of Scientific and Industrial Research also read the paragraph in the same sense, and accordingly attributed to turbulence the failure of certain high-speed bearings. It must, however, be admitted that another interpretation of the sentence quoted is possible, and in that case the sole responsibility for the error lies with the writer of the report in question, and Osborne Reynolds is acquitted and his shade entitled to an apology. That failure of lubrication is impossible from the cause suggested follows from two considerations. In the first place, even when a fluid is in turbulent flow there is a film along each solid boundary which remains in viscous flow. Any turbulence is accordingly confined to a core of fluid between these viscous films. As long as the bond between this film and the solid surface holds, some oil must be dragged in between the opposing surfaces, which can only come into contact if the shearing stresses developed are sufficient to tear these films away, a condition which has nothing to do with the turbulence. In the second place the formation of a turbulent core depends upon the least thickness of the layer of fluid. If such a core should form in a bearing it would immediately be squeezed out, thus reducing the thickness of the oil layer and automatically re-establishing the conditions for viscous flow. There is no practical lower limit to this least thickness of oil film since lubrication can be perfectly maintained with a film but a few molecules thick. It is of some interest to note that if a long smooth plank be drawn through a large mass of fluid the thickness of the viscous film is about $0 \cdot 36 \frac{\mu v}{R}$ centimetres. In this expression μ denotes the absolute viscosity of the fluid v the speed of motion in centimetres per second, and R the resistance experienced, measured in dynes per square centimetre. Unfortunately the numerical coefficient is not too well determined owing to the scantiness of the experimental data.—Ed. Eng.]

"SIXTH REPORT TO THE CORROSION RESEARCH COMMITTEE, INSTITUTE OF METALS."

To the Editor of Engineering.

Sir,—On reading the report of my remarks at the Swansea meeting of the Institute of Metals, page 371 of your issue of September 22 (discussion on Sixth Report to Corrosion Committee), I find that there are several misprints, to which, in the interests of accuracy, perhaps you will kindly allow me to call attention. They are as follows: "Fourth Report speculative in its findings"—"speculative" should read "*exclusive*." "Common products," should read "*corrosion* products"; "galvanic surface," "galvanic *couple*"; "partial separation," "*spatial* separation."

I would like at the same time to pay tribute to the remarkable celerity with which a complete report of the discussion appeared in your journal.

Yours faithfully,
W. H. J. Vernon.

Imperial College of Science and Technology, (Royal School of Mines), South Kensington, London, S.W. 7.
October 2, 1922.

"DOUBLE REDUCTION GEARS FOR TURBINES."

To the Editor of Engineering.

Sir,—I am pleased to learn from Dr. Hatfield's letter in your issue of September 22 (page 364), that my letter on the above subject in Engineering, of September 1, has caused interest, and I propose to reply to Dr. Hatfield's questions by giving very shortly my general views on this very difficult problem.

Although there is nothing new or novel in the points raised, and they have little bearing on my letter, I agree with what I take to be Dr. Hatfield's views—that a certain amount of trouble has been due to incorrect cutting of the teeth of the wheels and pinions, which leads to excessive local stress on portions of the teeth and, sooner or later, to failure through fatigue.

I also willingly admit that if the teeth of wheels and pinions were correctly cut and alignment, &c., good, that nickel steel of the highest quality would probably stand up to its work. This question of machining, however, is a matter as to which we, as steel manufacturers, cannot give any assistance; it can only be dealt with by the marine engine builders.

One point to be noted, however, is that whatever excessive stresses the pinion teeth have to stand up to are also transmitted exactly to the teeth of the wheels engaged, and I believe it to be the case, that these wheels rarely or never fail. That being so, it is obvious that if we can supply pinions made of steel of higher quality than the nickel steel generally used, the life of the pinions might be increased and made, at least, equal to the life of the wheels. It having been proved in practice that nickel steel is not equal to the excessive stresses sometimes met with, it is obviously the duty of the steel manufacturers to endeavour to supply a better material until such times as perfectly cut wheels and pinions can be universally supplied.

My views are that the required steel should be as free as possible from segregation and allied defects, that it should have a true high elastic limit to enable it to stand high local stresses without fatigue, and that it should have a high impact value without which, in my opinion, all steels are liable to be uncertain. My letter of September 1, with contained data, was to draw attention to the fact that pinions can be supplied made of steel complying with the above requirements.

Might I, in turn, ask Dr. Hatfield to favour us by again looking carefully over the diagrams and tests accompanying my letter, and giving us his candid opinion as a steel expert as to which of the two steels he would expect to stand up best against the overstrain, want of alignment, and general racket, which, from his questions, he knows sometimes to exist in a double reduction gear box.

In making a careful and unbiased survey of all the data available to us regarding this matter we are sure, and think Dr. Hatfield will agree with us, that occasionally defective machining has not been by any means the sole cause of trouble.

Yours faithfully,
Wm. C. Rowden,
(Sir W. G. Armstrong, Whitworth and Co., Limited.)

Ashton-road, Openshaw, Manchester.
Monday, October 2, 1922.

"EVAPORATION AND DISTILLATION."

To the Editor of Engineering.

Sir,—Will you permit me to thank Mr. Maclean for his courteous reply in Engineering of the 22nd ultimo, to my inquiry. When writing that inquiry I did not recognise in Mr. Maclean the representative in this country of the Prache and Bouillon system. Also, I confess that in my rough calculations at the moment of writing, I somewhat misapprehended the claims made in Mr. Maclean's statement, although they were set out clearly enough. If you will allow me I should like to traverse, as briefly as possible, the position as it appears to me in the light of the data so far disclosed.

To raise the temperature of 4 kg. of water, in the conditions stated by Mr. Maclean, to boiling temperature, and then to evaporate the 4 kg. into vapour, requires 2,424 kg. calories (1).

The work is supposed to be done by 1 kg. of primary steam at 192 lb. gauge pressure mixed with 4 kg. of vapour from the water evaporated. Assuming this mixture to be made in the manner shown without loss of heat, the total heat in the mixture would be 3,220 kg. calories (2); and the corresponding pressure in the heating chamber would be approximately 19 lb. gauge. But some loss must occur, and if we take the resulting pressure in the heating chamber to be 10 lb. gauge we shall be nearer the mark—Mr. Maclean does not give this pressure. The total heat in the water of condensation which will form in the heating chamber will then be 583 kg. calories (3), and this amount must be deducted from (2) to give the amount of heat apparently available for doing the work, which amount will therefore be 3,220 — 583 = 2,637 (4). There is thus left an apparent surplus of 213 kg. calories, which has to provide for excess water heated, radiation and other losses *and to do the work of compression*. I suggest that it is not enough, and, knowing well how easy it is to be misled in an evaporator trial, that more primary steam was used than has been debited.

The volume of vapour arising from the 4 kg. of water is 231 cub. ft., and this has to be compressed to 60 per cent. in 12 seconds. The efficiency of the "thermo-compressor" as a heat engine, which of course it is, cannot be more than 16·2 per cent. in the circumstances assumed. The heat added to the water vapour to raise its temperature from 0 lb. to 10 lb. is 46 kg. calories (5), and as this heat is proportionate to the total work done the total heat expended in effecting the necessary compression must be at least 284 kg. calories (6).

The account will then stand as follows:—

	Kg. Calories.
Total heat in 4 kg. water vapour ...	2,544
Heat added by compression	46
Heat in 1 kg. primary steam, 676 less 284 (6) expended in compression ...	392
Total heat	2,982
Deduct heat in water of condensation (3)	583
Heat apparently available	2,399
Deficiency	25
Net requirements (1)	2,424

There are still all the unavoidable losses to be provided for excess water heated, radiation, absorption, leakage, which might quite well run the deficiency up to many times the figure of the above statement. Even so, after making all the necessary allowances, a remarkable and valuable result appears to be achieved; and I am puzzled to know how it is that this system, which was formally tested by a French scientific body so long ago as 1909, has not come into more general use.

Possibly the explanation is to be found in the modesty of the French engineers. I have, I think, seen all that has appeared in the public prints of this country in reference to this system, and the first definite figures of a trial of the "thermo-compressor" which have been given are those given by Mr. Maclean in his communication published in your issue of the 11th ultimo; and those relate to a trial made in 1914. Even Mr. Maclean's figures cannot be regarded as complete; for instance, they omit a most interesting and important factor in the pressure maintained in the heating chamber of the evaporator. I therefore hope that Mr. Maclean may before long be able to give us the results of some trial of the system in this country made with all the necessary checks and controls. Meanwhile the valuable possibilities that appear to be associated with this system might very advantageously be made the subject of research in some competent engineering laboratory.

I remain, yours very truly,
A. J. Liversedge.

National Liberal Club, London, S.W. 1,
September 30, 1922.

To the Editor of Engineering.

Sir,—I am glad to see that Professor Hinchley has contributed to this discussion, and particularly to observe that he sees no difficulty in accepting the test figures recently published by me. The results were obtained by using a mean temperature drop as between the steam and the water of 4 deg. C. Special mechanical means for obtaining a rapid circulation, and therefore a high rate of heat transmission were not adopted in this case; the circulation is rapid, but due entirely to thermal considerations, and suitable design.

Regarding relative dimensions a well laid-out quadruple effect evaporator of the usual type with barometric condenser and pumps, known to the writer, occupies 35 ft. by 22 ft. floor space, while the height to top of bodies is 22 ft. and the condenser towers are, of necessity, much higher. A complete plant made by the writer's firm for exactly the same evaporative duty, but having a higher thermal efficiency, occupies a floor space 16 ft. square, and the highest point is 21 ft. 6 in. from the floor line. There are, of course, no condensers or pumps required. The comparative prices were as three to one in favour of the latter plant, while the additional economical advantages due to the size of building required and complete absence of moving parts are obvious.

Lest there be any apprehension that the plant is new or untried, it may be of interest to say that hundreds of these plants have been giving satisfaction on the Continent for years, and the writer's firm will be pleased if, as they hope, they can induce such a well-known authority on evaporation as Professor Hinchley to undertake an independent test, for publication, of one of their forthcoming British installations, which is at present being erected.

Yours faithfully,
Jas. B. Maclean.

2, Central Buildings, Westminster, S.W. 1.
October 3, 1922.

"ECONOMY IN THE USE OF MACHINE TOOLS."

To the Editor of Engineering.

Sir,—It is pleasing to note that one of our foremost machine tool makers, on page 408 of your current issue, is taking an interest in the economy and other advantages of technical knowledge as applied to industry. It is only those who have the technical knowledge who are in a position to demonstrate to those who lack it that confidence comes with technical knowledge. It enables him to overcome difficulties which, to the illiterate person, appear to be unsolvable. The saving possible in time and material is beyond the comprehension of all who do not possess that knowledge.

Who is responsible for so much of the present-day "inefficiency" to which Mr. Pickin refers? It is not the absence of technical books. It is rather the barriers which are placed before the existing and past generations which prevents knowledge from reaching the young machine man or "turner." For instance, should a representative of any well-known technical book company attempt to approach the workers in any factory with a view to placing before them, not text books, but books compiled by those whose authority is acknowledged to be pre-eminent—in facts and formulas, principles and practice in all branches of engineering—the answer is that "the works manager is at present engaged"; if an interview can be arranged the unfailing answer is, "we don't object to you interviewing our young men in the street, but we certainly cannot allow you to enter our works' canteens during the lunch interval, to place before them such books."

Mr. Pickin remarks that the subject is a vast one and too great for any one firm to tackle. Therein lies the whole trend of the economic question. The British employer is too conservative; if he holds the key to the cost of production in certain process of manufacture, it is locked up within his works, and a notice is displayed to the effect that no callers are entertained. Until that spirit is developed into a broader outlook, co-operation, standardisation and centralisation will always be handicapped.

Yours faithfully,
Robert Keddie.

12, Venus-road, Eltham, S.E. 9, October 2, 1922.

THE NON-RADIATING ATOMS.

To the Editor of Engineering.

Sir,—I should like to call attention to a statement attributed to Professor Lindemann during the discussion on "The Origin of Magnetism," at the Hull meeting of the British Association, and published in Engineering of September 29 last (page 389), viz., that "we" could not possibly accept Oxley's suggestion that the structure of the atom may be regarded as static when the atom is not radiating and dynamic when it is radiating. At the meeting I was not able to hear the whole of Professor Lindemann's remarks, but I realise now that he is under a misapprehension as to what I have implied by a static non-radiating atom. My remarks, as quoted in

Engineering, distinctly emphasise that the electron is not merely a simple electrostatic charge, but also a magneton. There appears to be considerable evidence from C. T. R. Wilson's experiments on the spiral character of the tracks of β-particles that the electron has the property of a magnetic doublet. The non-radiating atom to which I referred is only static in the sense that the motion of the electrostatic charge is highly localised when compared with atomic dimensions. It is this motion in a minute orbit which endows the electron with a magnetic moment, the electron being not only a unit electrostatic charge but a unit magnetic doublet or magneton. The resultant magnetic forces between pairs of such doublets are capable, in my opinion, of determining the directional forces required to explain non-ionised crystalline structures, magne-crystallic action and the forces of chemical combination in non-ionised compounds. It is here where the close correspondence between this and the Lewis-Langmuir theory is definitely marked.

The laws which govern the localised electron motion in a non-radiating atom are unknown, but it is possible that the electron itself may be quantized. In the writer's opinion, the passage from such a localised motion to the open elliptic orbits of Bohr and Sommerfeld involves no greater strain on the imagination than does the conception of the mechanism or the forces involved when an electron passes from one non-radiating Bohr-Sommerfeld orbit to another, which latter, I think, perplexes Professor Lindemann as much as it does everybody else.

Professor Lindemann protested against the undue prominence given to the Ewing-Whittaker model, but I welcome its advent as a simple and promising line for the development of future research. It is altogether a new outlook on the subject of atomic structure, based at least on rational lines, and therein lies its power.

Yours faithfully,

A. E. Oxley.

29, Amherst-road, Withington, Manchester.
October 4, 1922.

Institution of Electrical Engineers.—Students' Premiums.—The Council of the Institution have recently awarded six students' premiums, of the value of 10*l.* each; and three scholarships, two of 50*l.* each and one of 40*l.*

British Industries Fair (Birmingham), 1923.—The council of this fair, whose offices are at the Chamber of Commerce, 95, New-street, Birmingham, ask us to state that the fair will be held at Castle Bromwich, Birmingham, from February 19 to March 2, 1923. The fair is held under the auspices of the Board of Trade, and is organised and controlled by business men for business men. Applications for space should be sent to the general manager, at the above address, at the earliest possible date.

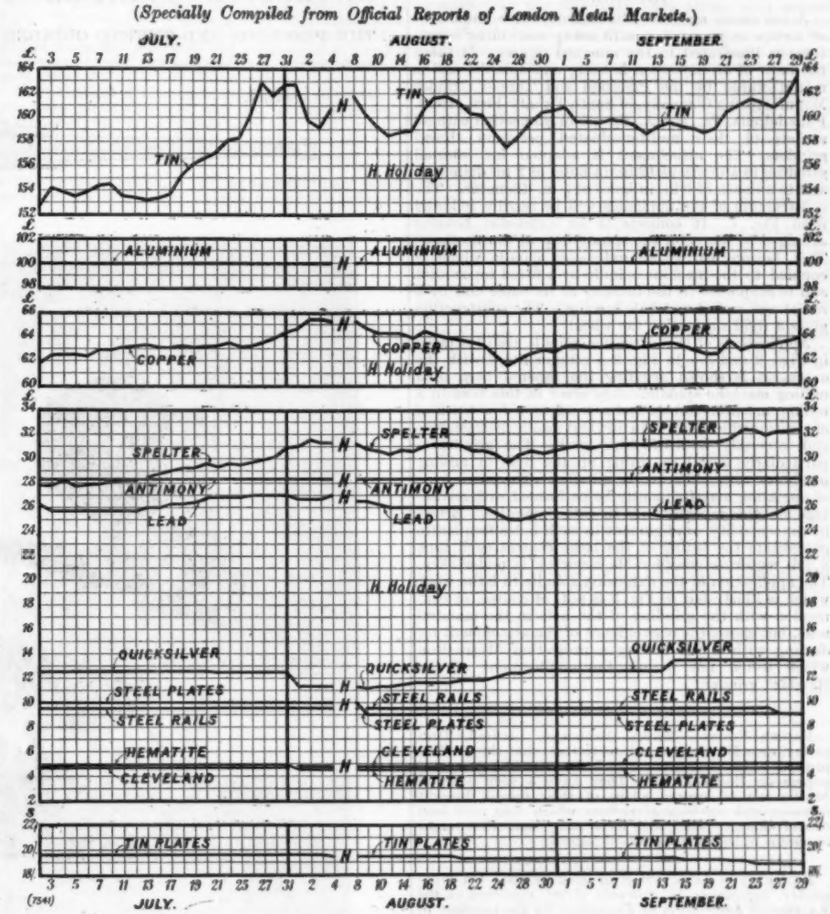
University of London, University College.—A course of 10 lectures on "The Utilisation of Water Power" will be delivered by Mr. Theodore Stevens, M.Inst.C.E., M.I.Mech.E., M.I.E.E., on Mondays, at 5 p.m., beginning the 16th inst. The syllabus is as follows: Fundamental Principles and Practice; Measurement and Survey; Best Utilisation of available Power; Storage of Water *v.* Auxiliary Power; Dams, Waterways, Tunnels, Pressure Pipes; Equipment of Low Head Plants; Equipment of Medium Head plants; Equipment of High Head Plants; Niagara Plant, 1851–1922; Future Water Power Developments. The lectures will be illustrated by lantern slides. Application for tickets of admission should be made to The Secretary of University College, Gower-street, W.C. 1.

The Federated Malay States Railways.—The report for the year 1921 for the railways of the Federated Malay States shows that these lines had a revenue for the year of 1,889,816*l.*, against an expenditure of 1,831,302*l.* The net profit was thus 58,514*l.*, against 65,704*l.* in the previous year. The revenue was 6·45 per cent. less than that of the previous year, while the expenditure showed a decrease of 6·31 per cent. The return on capital expenditure which the net profit represents is 0·29 per cent. During the year goods rates were increased, with the result that they brought in an additional 117,000*l.*, but the passenger traffic fell off over 21 per cent. The steamer and ferry services showed a profit of 8,565*l.* compared with a loss of 9,747*l.* in the previous year. The expenditure of capital during the year was nearly 3½ millions sterling, the bulk being spent on widenings and additions, on new lines and on rolling-stock.

The Panama Canal.—The report for the year ending with June 30, 1922, for the Panama Canal, does not show up quite so well, as regards commercial tonnage making use of the Canal, as did the previous year. The total commercial tonnage (Panama Canal measurement) was slightly greater in 1922 than in 1921, but the number of ships passing, and the cargo tonnage fell off. The latter represented 10,884,910 tons compared with 11,599,214 tons, while the number of vessels, 2,736, showed a decrease of 156. The commercial cargo passing through the canal since its opening now amounts to over 61,000,000 tons. Of this figure, 24,000,000 tons represent United States shipping and 21,500,000 tons British shipping. The greatest traffic over any specified route is that of the United States coastwise trade. In point of cargo tonnage this was about double in 1922 what it was in 1921. Next in volume is trade with the Far East, with a preponderance eastwards, as vessels having passed through the canal on the outward journey frequently completed the round by way of Suez.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



Note.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given, in the case of steel plates are for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for the East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of tin-plates is per box of I.C. cokes f.o.b. at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

The German Iron and Steel Trade.—In the course of an article in *The Iron Age*, New York, it is stated that in 1913 and 1914 Germany stood second only to the United States as a producer of pig-iron and steel, and that is her rank to-day, four years after the end of the great war. As a factor in world competition, Germany is still to be reckoned with, the alternative of her political and industrial collapse being unthinkable, in spite of the *debacle* in the mark, which has led to so many gloomy predictions in recent weeks. Thus far, in 1922, she has been second only to Great Britain as an exporter of steel.

Buffer Stop Collision at Ealing Broadway.—On July 11 of this year an accident occurred at Ealing Broadway Station when a Central London Railway passenger train ran into a buffer stop. The report on this accident has just been issued. It is signed by Colonel J. W. Pringle and attributes the accident to an error of judgment on the part of Guard Topley, who was operating the train. It is the practice on these lines to pass guards as emergency motor men, so that they may be able to bring their train in should anything happen to the regular motor man. After passing their tests these men are given at intervals practice duty, so that they may remain efficient, a regular motor man always being in the cab on such trips, as well. In this instance, the regular motor man present apparently endeavoured to regain control of the train when it was realised that Topley had not allowed sufficient margin, but it was not possible to avert the collision. Colonel Pringle states that the arrangements made by the company for exercising these men do not call for any alteration. The precautions taken certainly appear to be all that can reasonably be expected, while the custom of giving the men experience at intervals is certainly very desirable.

"The Generation and Utilisation of Cold."—The Faraday Society and the British Cold Storage and Ice Association will hold a joint meeting on Monday, October 16, to discuss the present position of the above subject. The meeting will be held at the Institution of Electrical Engineers, and it will be divided into three sessions, from 2.30 to 4, 4.45 to 6, and 7.45 to 10 p.m. At the first session, following a general introduction by Professor Alfred W. Porter, F.R.S., President of the Faraday Society, the subject to be discussed will be "Laboratory Methods of Liquefaction and Methods of Measuring Low Temperatures." The opening address will be delivered by Professor H. Kamerlingh Onnes and Dr. Crommelin will give a description of the equipment of the Cryogenic Laboratory at Leyden. Subsequent contributors will include Professor C. F. Jenkin and Dr. Ezer Griffiths. The second and third sessions will be devoted to "Industrial Methods of Liquefaction and Practical Applications of Low Temperatures." The general introduction to this subject will be given by Mr. K. S. Murray, of the British Oxygen Company, Limited, and among those who will contribute papers will be Monsieur Claude, on "The Industrial Manufacture of Hydrogen by the Partial Liquefaction of Water Gas"; Mr. E. A. Griffiths who will deal with the subject as it touches aeronautical work. Messrs. Liquid Air, Limited, will arrange some demonstrations during the intervals and will also contribute information on the Heylandt system of air liquefaction and on the use of liquid oxygen in blasting. Invitations to attend the meeting have been extended to members of the London Section of the Society of Chemical Industry and to the Physical Society of London. Others desirous of attending are invited to communicate with the Secretary of the Faraday Society, at the offices, 10, Essex-street, London, W.C. 2.

EXTENSION SPINDLE FOR INTERNAL GRINDERS.

A grinding machine attachment which should be of service in connection with many machining operations is illustrated in the annexed figures. It takes the form of an extension housing and spindle, and is manufactured by the Precision and Thread Grinder Manufacturing Company, of South Twenty-First-street, Philadelphia, Pa., U.S.A., for use in connection with all models of their multi-graduated precision thread grinders. The attachment is adapted for internal grinding to a depth of 12 in. in holes of 2 in. diameter, and to a depth of 6 in. in holes of ½ in. diameter. The construction of the appliance will be readily followed from Fig. 1. It consists of an extension housing arranged to screw on the spindle cap of the machine. This housing carries an extension spindle which is coupled to the machine spindle by a fitted taper joint and is supported in the housing at its outer end by a radial and end thrust ball bearing. The construction gives a rigid support to the wheel.

Applications of this extension spindle are illustrated in Figs. 2 and 3. In Fig. 2 a grinder fitted with the extension is shown grinding the tapered bore in a milling machine spindle. Any error in this bore in a milling machine throws undue work on a few teeth of any cutter which may be in use, and results in chattering and generally unsatisfactory work. The grinder is particularly useful in truing up the hole in milling machines with unhardened spindles. The same type of operation may frequently be performed with advantage on the tapered hole in lathe spindles. Errors in concentricity or alignment in such holes frequently necessitate the truing of the lathe centres each time a job requiring considerable accuracy is undertaken. The application of the extension spindle to lathe work which is illustrated in Fig. 3 is not, of course, in connection with the grinding of the hole in the mandrel nose, but shows the convenience of the attachment for dealing with a job having a projecting obstruction which would not permit the employment of the standard grinder.

Boiler Firing.—Messrs. Meldrums, Limited, Timperley, near Manchester, ask us to state that they will be pleased to be of assistance to lecturers wishing to give papers on Boiler Firing. They have a very comprehensive set of lantern slides of their forced draught furnaces and mechanical stokers which they will lend free of charge. They also have many data that might be useful in the preparation of papers.

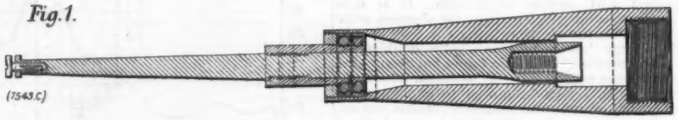
Manchester Association of Engineers.—On Wednesday, September 27, upwards of 200 members of the Manchester Association of Engineers, by the courtesy of the directors of the Metropolitan Vickers Electrical Company, Limited, had the opportunity of viewing the firm's extensive works at Trafford Park. As evidence of the size of these works it may be stated that the area is about 72 acres and the normal number of employees 8,500; apparently at the present time practically all the departments are busy. Among a number of interesting contracts, several which are being completed for the Manchester Corporation attracted particular attention. Chief among these were two 25,000-kw. turbo alternators, two 25,000-kw. turbines and six 19,500-k.v.a. transformers for the new generating station at Barton. The normal capacity of the Metropolitan Vickers generating plant, it was explained, was 4,000 kw. The firm is now engaged, however, in building a sub-station to take power in bulk from the local supply authorities to replace the works generating plant. The new sub-station will have an ultimate capacity of 5,000 kw. mixed alternating and direct current.

Institution of Engineers and Shipbuilders in Scotland.—The sessional meetings, for reading and discussing papers, will take place in the Rankine Hall, at 39, Elmbank-crescent, Glasgow, on the following Tuesdays, at 7.30 p.m.:—1922—October 24, November 21, December 19; 1923—January 16, February 13, March 13 and April 10. At the opening meeting on the 24th inst., the president, Mr. Harold E. Yarrow, will deliver his address. The following subjects will be submitted for discussion during the session: "Sea Power or Air Force," by Lieutenant-Colonel Sir Alan H. Burgoyne, M.P.; "The Treatment of Mild Steel," by Dr. Walter Rosenhain, F.R.S.; "Radio Telephony," by Professor G. W. O. Howe, D.Sc.; "The Development of the Sulzer Diesel Engine," by Engineer Lieutenant-Commander L. J. le Mesurier, R.N.; "Some experiments on an Oil Engine," by Mr. A. I. Nicholson; "The Beardmore-Tosi Diesel Engine: Test-Bed Results and Sea Trials," by Mr. Robert Love; "Electrical Transmission of Power as Applied to Propelling Machinery," by Mr. W. J. Belsey; "Electrical Appliances on Modern Vessels," by Mr. J. S. Rankin; "Vane Wheels for Ship Propulsion," by Mr. Maurice E. Denny; "Launching Velocities and Drags," by Professor Percy A. Hillhouse, D.Sc.; "The Application of New Freeboard Regulations," by Mr. A. Chisholm; "The Longitudinal Strength of Bulk Oil Carrying Vessels," by Mr. T. R. Thomas and Mr. James Turnbull; "Modern Passenger Liners," by Mr. T. N. S. Dickson; "The Arch Principle of Ship Construction," by Mr. Maxwell Ballard; "A New Method of Boat Lowering," by Mr. Colin D. McLachlan.

EXTENSION SPINDLE FOR INTERNAL GRINDERS.

THE PRECISION AND THREAD GRINDER MANUFACTURING CO., PHILADELPHIA, U.S.A.

Fig. 1.



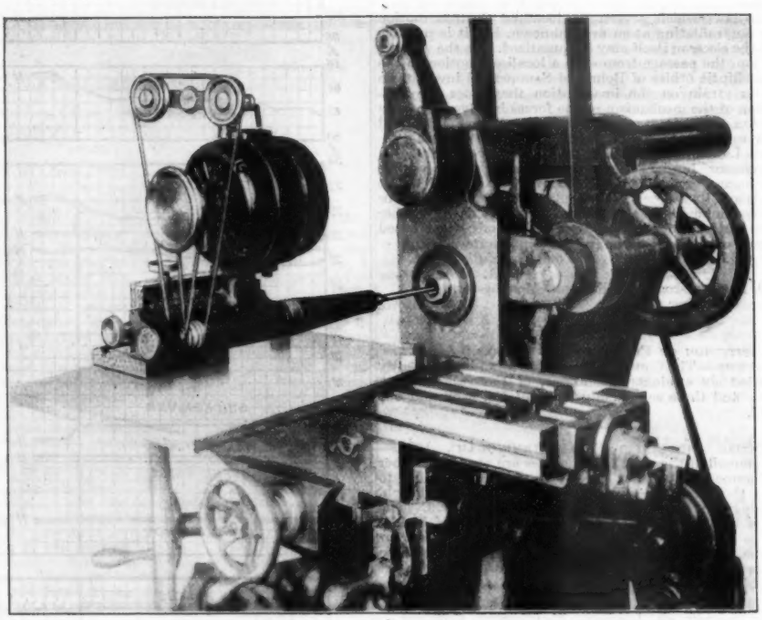


Fig. 2.

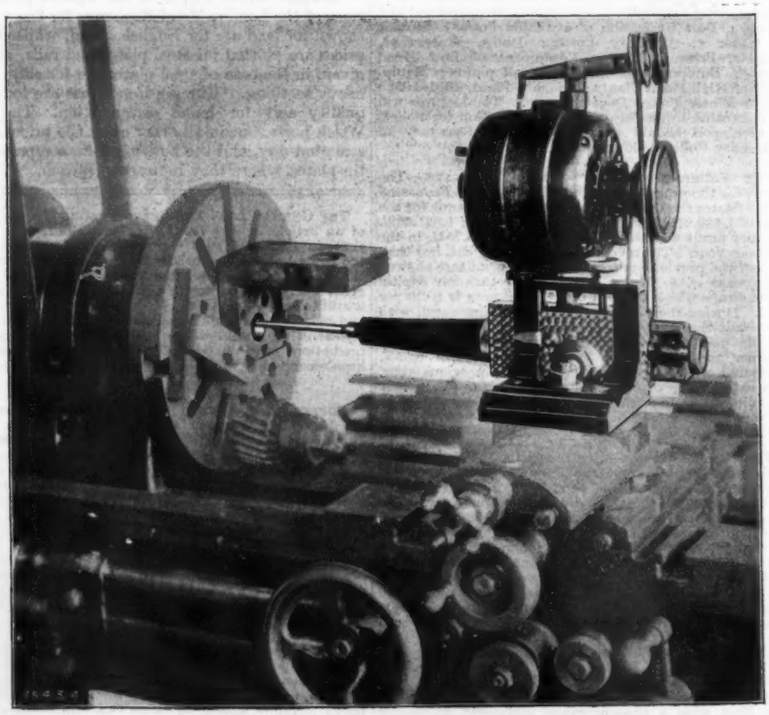


Fig. 3.

WHITE METALS.*

By A. H. MUNDEY, Member (London); C. C. BISSETT, B.A., B.Sc., B.Met., Member (London); and J. CARTLAND, M.C., M.Sc., Member (Manchester).

THE authors review the principal classes of white metals, their composition and physical properties, chiefly in relation to their uses and manufacture, and consider their constitution only so far as the user and manufacturer are directly interested.

Anti-Friction Alloys.—Experience has established the opinion that a homogeneous metal is not suitable for a bearing, that neither a single metal nor an alloy which is a solid solution can be employed with success, and that either a metal consisting of a soft matrix with hard crystals embedded in it, or a hard metal interspersed with veins of a softer constituent, has the necessary surface for a practical bearing alloy. There can be little doubt that the best service is obtained from an alloy which, though wanting in homogeneity, has its undissolved constituents distributed in a regular and uniform manner. The authors are of opinion that this mottled surface, in which the harder portions are in slight relief, provides a number of pools and canals which serve to retain the oil film, and, on account of their fine and even distribution, promote the spreading of the oil over the surface by a function which is closely related to capillarity.

The usual tests for tensile strength, hardness and compression have been made on representative alloys. The test-pieces were prepared by casting into a cast-iron stick mould under uniform conditions. The temperature of casting was about 350 deg. C., the mould being heated to approximately 100 deg. C. The acting portion of the test-piece was 0·564 in. in diameter, the length being 2 in., according to the usual formula $L = 4\sqrt{\text{area}}$. The Brinell tests were all taken with a 10-mm. ball at a uniform load of 500 kg. The compression tests were made by taking cylinders 0·564 in. diameter by 0·5 in. high. The first observation was made when a permanent deformation of 0·001 in. was produced, the ultimate figures when the test-piece was compressed to one-half its original height. (The paper gave the test figures for each alloy.)

The choice of a bearing metal is often controlled by consideration of first cost, and this feature is probably responsible for many disappointments and troubles. Tin being the most expensive constituent of the usual white bearing metals, the proportion of tin mainly affects the price.

For engine bearings for automobile and similar services, the first seven of the following alloys may be looked upon as good representative types:—(1) Tin, 93 per cent.; antimony, 3·5 per cent.; copper, 3·5 per cent. (Figs. 1 and 2). (2) Tin, 86 per cent.; Antimony, 10·5 per cent.; Copper, 3·5 per cent. (Figs. 3 to 5). (3) Tin, 83 per cent.; antimony, 10·5 per cent.; copper, 2·5 per cent.; lead, 4 per cent. (4) Tin, 80 per cent.; antimony, 11 per cent.; copper, 3 per cent.; lead, 6 per cent. (5) Tin, 60 per cent.; antimony, 10 per cent.; copper, 1·5 per cent.; lead, 28·5 per cent. (6) Tin, 40 per cent.; antimony, 10 per cent.; copper, 1·5 per cent.; lead, 48·5 per cent. (7) Tin, 20 per cent.; antimony, 15 per cent.; copper, 1·5 per cent.; lead, 63·5 per cent. (8) Tin, 78 per cent.; antimony, 11 per cent.; copper, 11 per cent.; lead, nil. (9) Tin, 5 per cent.; antimony, 15 per cent.; lead, 80 per cent. (Fig. 6).

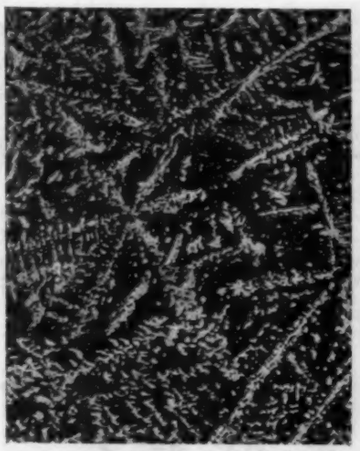


FIG. 1. No. 1 alloy, showing copper-tin constituent. × 100.

FIG. 2. No. 1 alloy, seriously overheated. × 100.

FIG. 3. No. 2 alloy, rapidly cooled from 350 deg. C. × 100.

FIG. 4. No. 2 alloy, slowly cooled. × 100.

Testing of Bearing Metals.—The method employed by the authors was as follows: A Thurston machine designed for oil testing had its bearings replaced by others of exactly similar form in the several alloys to be tested. Trial runs, using these bearings under similar conditions as to pressure, speed, and duration, were made, and figures obtained in (*a*) rise in temperature per 1,000 revolutions, (*b*) coefficient of friction as shown by the tendency to seize and indicated by the swing of the pendulum of the machine. The drawback to these trials consisted in the fact that some alloys were suitable for light loads and fast speeds, whilst others were more efficient for heavy loads and slower running. Actual comparisons are therefore not correct. In all cases the bearings are freely lubricated, usually by pad lubrication.

There is always to be noted the degree of finish of the bearing; this is met by the only reasonable method of boring and scraping the bearing to the highest possible degree of refinement in workmanship. The human element, represented by the skill of the mechanics, cannot be eliminated.

It would be difficult to overstate the necessity for constant care and observation, as to the temperature and casting conditions, in the use of the white bearing metals. The effects of these varying conditions were convincingly presented by Fry and Rosenhain* in their observation on a typical bearing metal, and it is very easy for errors in judgment or manipulation to arise under the conditions which frequently obtain in service. The metal in a ladle becomes slightly cooled, solidification of certain constituents commences, and the pouring is hurried, virtually a liquation process ensues, and the necessary hardening constituents remain behind in the ladle. On the other hand, if the tendency to solidify is noticed and the metal is reheated sufficiently to obtain rapid resolution, serious overheating with consequent damage will result.

The remarks by Fry and Rosenhain on hammer dressing of bearings are confirmed by the experience of the authors. It is known that this is a custom which is well established, the evident intention being to consolidate the material by cold-working. In reality it has a slight softening effect, and in those alloys in which the hard constituents are closely packed the crystals are seriously crushed, and, by the destruction of their natural orientation, their interlocking is diminished and the alloy is weakened, or in some cases even cracked.

Summary.—(1) The chief value of white bearing metals is due to the way in which they maintain the oil film. This is effected by the hard constituents standing up *in use* in slight relief, the softer matrix thus forming numerous evenly distributed channels, which maintain the oil by capillarity.

A single metal, or a metal consisting of a solid solution, will not function as a bearing metal.

(2) In the tin-base bearing metal the copper-tin c crystals solidifying out first entangle the cuboid tin-antimony crystals which subsequently form and prevent their segregation, thus ensuring even distribution.

3. The functions of tin-base and lead-base alloys are similar; the latter could be much more generally used than is the case at present, the chief differences being the action of the copper tin crystals mentioned in (2) and the fact that the matrix in the tin base is tougher.

(4) The greatest care and skill must be exercised in the handling of bearing metals in practice, otherwise either the hardening constituents will be left in the ladle by liquation or the metal will be overheated and the structure spoilt.

Printers' Alloys.—The application of white alloys to the art of printing involves a much larger amount of technical consideration than is usually supposed, and the industry is a very important one.

In the days of hand composition, when single movable type was universally employed, the problem was a comparatively simple one from a metallurgical standpoint. An immense amount of printing is still carried out from type set up in the formes by hand, but a much greater volume of work, as in the case of newspaper, periodical and large editions of book production, is turned out by employing machine type-setting, as in the linotype, typograph and intertype machines.

The metal generally used for linotype work is approximately of the composition 2·5 per cent. to 3 per cent. tin, 10 per cent. antimony, 87 per cent. to 87·5 per cent. lead. This alloy solidifies at about 238 deg. C., and has no prolonged period of solidification (it corresponds to the eutectic in the majority of the alloys). This is necessary, as the operations of casting, solidification, trimming and ejection are so rapid in succession. The requirements are an absolutely fluid and mobile metal, absence of contraction, thus ensuring a sharp casting, rapid solidification, and only the slightest expansion on solidification, or the ejection of the slug is hampered.

The alloy is the softest and weakest of the series. This does not matter, as the long slug gives mass support to the type, to resist the compressive and slight bending stresses in service.

Purity of the constituent metals is most important, traces of copper giving rise to a constituent which solidifies about 40 deg. C. higher than the bulk, and clogs up the holes of the mouthpiece. Zinc is fatal; it is not soluble in the alloy, but forms spongy, soft solid masses. Nickel, iron, sulphides and oxides are sure causes of trouble.

The intertype, linograph, typograph, and similar machines are much like the linotype in principle, the metal used is practically the same, but as the apertures to the moulds are in some cases larger and in slot form instead of a series of holes, a slightly harder metal is permissible in these—that is, one containing a higher proportion of tin and antimony.

The other important machine for type-casting and setting is the monotype. The type cast are single and separate, they therefore require to be stiffer and harder than those cast into line slugs, not having the mass support of the latter. There are, however, compensating advantages; the small size favours very rapid solidification, more tin and antimony can be employed in the alloy without risk of dangerous segregation, and type of extremely fine face can thus be produced.

A good average alloy for monotype is tin 8 per cent.,

* Abstract of a paper read at the meeting of the Institute of Metals on Wednesday, September 20, 1922.

* ENGINEERING, vol. cviii, pages 437 and 563.

antimony 15 per cent., lead 77 per cent. These alloys vary, as some great printers require a higher grade of metal containing up to 10 per cent. tin and 20 per cent. antimony; to produce type of the highest class from this metal considerable skill and experience are necessary.

During the passage of the molten metal through the small nozzle or through the aperture of the valve, a momentary cooling below the critical temperature is liable to cause a deposition of tin-antimony alloy, thus partially closing the aperture and causing delay. The presence of small quantities of copper accentuates this feature and difficulty, as the formation of copper-tin crystals is still more liable to cause trouble.

It has been found that cast-iron is more suitable than mild steel for the nozzles and valves, as tin-iron alloys are formed in the latter case, due to the prolonged contact of rich tin alloys with the iron at the temperature of working, causing rapid corrosion at the apertures.

The necessity for temperature control is evident. Even a draught of cold air from an open window upon the melting pot of the machine causes a cooling at the surface and a partial solidification and segregation of the tin-antimony compound. When this occurs, it is necessary to raise the temperature of the whole contents of the pot very considerably to effect a rapid re-solution of the separated constituent. Further rapid oxidation and formation of excessive dross thus occurs.

The third group of printers' alloys are those called stereotype metals, in the application of which many metallurgical problems arise. The alloys used for stereotype work vary with the nature and importance of the service.

The stresses on the metal in use are twofold. First compressive, and secondly there is, in the rotary presses, the abrasive action wearing down the sharpness of the type face and thus making indistinct print, and also a slight bending stress on the type, causing distortion. The continuous application of these stresses in working can be imagined when it is remembered that in producing a great daily paper upward of 48,000 impressions are taken from one plate in 1 hour to 2 hours. A nickelled flat plate will give 250,000 impressions.

Casting temperature is very important, generally about 300 deg. to 330 deg. C., although in some cases it is distinctly lower. In cases where the metal is cast under pressure from a pump, it is actually introduced into the mould in a condition not perfectly fluid, that is, crystals of tin-antimony alloy have separated out in a soft solid state. The metal must be as uniform as possible, and cooling must be reasonably rapid to prevent massive segregation or the plates are likely to be ruined. Water cooling is resorted to in more elaborate apparatus.

Fig. 7 shows a portion of an illustration magnified 100 diameters, the dots being those produced by the photography through a half-tone screen, 180 by 180 mesh to the inch. Fig. 8 is an etched specimen of stereotype plate.

Too high pouring temperature causes occlusion of gases, and consequent sponginess, or what the printer terms "cokey face." Irregular cooling or composition causes sinks, or local contraction, making white spaces on the printed matter.

Copper is sometimes used as an extra hardener; this is effected by the formation of the hard copper-tin and copper-antimony compounds. Much skill is required by the operators using copper-hardened alloys, as the tendency to separation in the melting and pouring, and the segregation of very hard constituents, is considerable.

The provision of metal for printers, also includes the making of spacing material for insertion between type. The dimensions require to be most exact, a variation of 0·001 in. being the utmost allowable. It is found that in an alloy of 15 per cent. antimony, 3 per cent. tin, 82 per cent. lead, this is quite possible, the contraction after casting in a highly finished steel mould being practically inappreciable.

The spacing between the lines is made by so-called "leads," which are cast in an alloy of slightly lower tin-antimony content. These are made, in some cases, by simple casting and machining, but in the more interesting process they are cast in the form of continuous ribbon about 0·75 in. wide by 0·1 in. thick. This is subsequently rolled with great accuracy to the required thickness. The rolling of these lead-base alloys temporarily softens them, but they are much tougher and more flexible than the cast strips. Ageing gradually restores their hardness so far as can be shown by the Brinell test. Many experimental tests have been carried out, with a view to getting more exact information on this feature. The great increase in toughness and flexibility of the rolled material compared with the cast strip gives the impression of softness. No difference in resistance to compression can be detected. An average of a number of Brinell tests gave before rolling 28·4 and immediately after rolling 27·5.

It will be recognised that the printing alloys are subjected in ordinary service to conditions to which no others are called upon to submit. They are cast, submitted to rapid and considerable mechanical stresses and then re-melted constantly, the whole cycle of operations being repeated daily for long periods, extending to months and years. The conditions of re-melting, frequently by persons of little skill, in many cases leave much to be desired; scraps of zinc, copper, brass and nickel are apt to be accidentally introduced, whilst the constitution of the alloy is such as favours separation into two or more constituent compounds in the melting pot, the tin-antimony compound tending to come to the top on account of its lower specific gravity. Further, this lighter compound is more readily oxidised, forming dross which has to be removed by skimming, gradually impoverishing the alloy of its necessary constituents. To remedy this renewal alloys are employed which consist of carefully graded high antimony-tin alloys with lead, proportioned to the particular alloy to be brought up to specification. The addition of tin antimony by this method is found to be much more convenient and effective than by the simple addition of these metals unalloyed. The elimination of impurities in these alloys is carried out by a very careful process of liquation, poling and drossing; these operations cannot as a rule be effected in the printing offices, and the metal has to be brought to the refinery if it has become seriously contaminated.

Zinc is particularly troublesome in the metal, as it does not dissolve, and, further, it collects around it particles of tin-antimony compound, which it brings to the surface. It is sometimes removed by very extravagant drossing or by serious and wasteful overheating, steaming, poling, &c. These operations are expensive, slow, and not very effectual. In the authors' works the method employed is by the application of a mild thermit interaction, whereby the impurities are oxidised at the expense of appropriate metallic oxides, the formed oxide being dissolved by a flux immediately it is produced, and it is subsequently removed by careful skimming. The principle is quite simple, but experience and skill are required in carrying out the operation, as these reactions are reversible, and small errors in temperature or manipulation are apt to restore the impurity to the bath of metal.

Fusible Alloys.—Fusible alloys can be manufactured with any desired melting point from 60 deg. C. upwards. The best known being Woods' alloy, containing bismuth 50 per cent., lead 25 per cent., tin 12½ per cent., cadmium 12½ per cent., which melts at approximately 70 deg. C. The application of these alloys is now limited to the manufacture of sprinklers for fire alarms and other special uses. During the war fusible alloys had an interesting and extensive application in the manufacture of aeroplane tanks of complicated design. A solid casting was made in fusible alloy the shape of the required tank, this was then immersed in a copper-plating bath, and the necessary thickness of copper to form the tank deposited thereon, the whole was then placed in boiling water and the fusible "core" melted out.

Alloys for Chemical Vats, &c.—The employment of lead-antimony alloys for valves, cocks, pumps, and similar gear for use in chemical works with acids and other corrosive liquids is very common and well known. The authors have, however, been engaged during the past two years in a considerable extension of this class of work. It has been found possible by the careful elimination of impurities, such as oxides, sulphides, traces of zinc, &c., to produce alloys with antimony content (varying according to the type of service) of from 6 per cent. to 8 per cent., which are equal to sheet lead in resistance to corrosive fluids, and which are capable of being cast into large vessels, such as vacuum evaporators, acid eggs, and tanks up to 10 tons in weight. The tensile strength varies from 3·98 tons to 4·28 tons per square inch. Castings are reasonably rigid and sharp. The chief advantage to the chemical engineer, however, is in the replacement by these alloys of iron or steel vessels lined with sheet lead. In the use of the latter, the iron casing expands and contracts with varying temperatures, but the sheet-lead lining expands but does not resume its former dimensions on cooling; gradually this accumulative expansion causes folds or creases, and subsequently cracks appear and the acid or other corrosive fluid attacks the casing, with serious results. The temperature of pouring should be as low as possible, consistent with perfect fluidity, and arrangements should be made to effect rapid cooling, as a fine uniform structure is an important feature in the resistance to action of corrosive fluids. The built-up tank from plates cast in iron moulds is therefore to be desired.

Die Casting Alloys.—The production of spacing material for printers is probably one of the earliest commonly used examples of die-casting, the operation being carried out under pressure in specially designed machines, but as this is for a specialised industry it has never been regarded as die-casting in the sense of the present use of

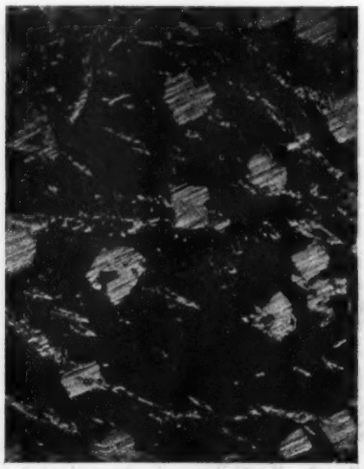


Fig. 5. Alloy No. 2, overheated. × 100.

Fig. 6. Magnolia metal. × 100.

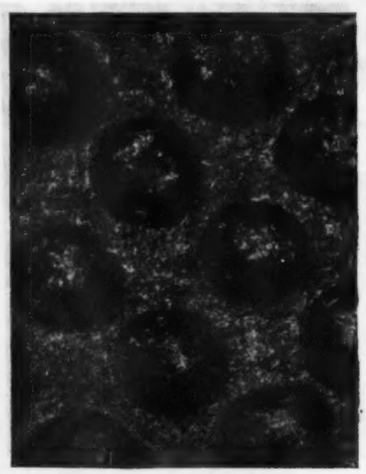


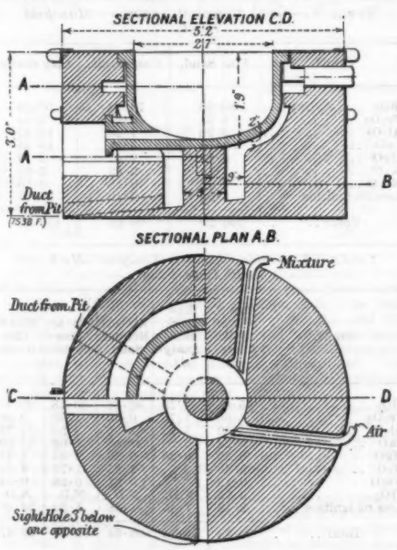
Fig. 7. Unetched portion of stereotype plate, showing the dots produced by photography through 180 × 180 screen. × 100.

Fig. 8. Etched specimen of stereotype plate, similar to No. 7. × 100.

that description. The white metal alloys used in die-casting for general engineering productions are numerous; they include (*a*) zinc-base, (*b*) aluminium-base, (*c*) tin-base, and (*d*) lead-base alloys. Actually the subject covers such a wide field that a whole paper could be devoted to its consideration. In view of the fact, however, that at the present time several committees, composed of users and producers, are studying this matter with a view to the standardisation of methods and information, it is not proposed to discuss the metallurgical aspects of it further. The production of die-castings on a large scale is still in a limited number of hands. The designers of tools and machines, the more highly skilled tool makers and also casters form a comparatively small fraternity. Experience in the construction and material of the dies, the selection of alloys, casting

FIG. 9. 2-Ton Melting Pots in Use. Pouring and Stirring.

Fig. 10 SECTIONED PLAN & ELEVATION OF 2-TON MELTING POT.



temperatures, and pressures is all important, and no descriptive directions can possibly replace it.

The much abused method of trial and error, otherwise exhaustive experiment, is frequently the only one possible in the production of difficult die-castings in so far as the determination of best form of gates, temperature of casting, and similar details of workshop practice.

The tools for this work are generally of mild steel or cast-iron, with special parts of tool or high-carbon steel. Alloy steel, vanadium, or nickel-chrome are occasionally used, especially for pressure cast aluminium base alloys. The high cost and also the difficulty in using alloy steel limits their general use. The problem of melting-pot material for the aluminium alloys is by no means solved. The authors have tried practically every well-recommended iron or nickel alloy; none so far has proved to be quite satisfactory. The aluminium gradually absorbs iron or nickel, in serious proportions.

Production and Refining.—Considerable experience in the preparation of white metals has led the authors to the opinion that the operations are best performed in gas-fired furnaces; in co-operation with the technical staff of the South Metropolitan Gas Company, furnaces and melting pots which are very efficient and economical have been devised. Alloys containing copper required for hardening and similar purposes are prepared in a gas-fired tilting furnace. The addition of these hardening alloys is made to the bulk metal whilst both are in a molten condition.

Refining by liquation is carried out in reverberatory liquation hearths also gas-heated, and the processes of melting and mixing of all usual alloys are performed in melting pots of a special design, a diagram and illustration in work of which are shown in Figs. 9 and 10. Town gas at ordinary pressure and air at a pressure of 4 in. mercury are employed; they are mixed before entering the combustion chamber, and the jet is introduced tangentially, so that the flame circulates round the pot, which is supported on a brick pillar, thus relieving the weight on the upper flange. A further supply of air is introduced somewhat in advance of the mixed jet. This ensures complete combustion; after the furnace has been running for a short time a certain amount of preheating is effected, which makes for economy. The brickwork after a time retains sufficient heat to carry on for several hours after the gas is extinguished.

The facility of control and the extreme cleanliness and convenience in handling are important features. The melting pots are bottom pouring, the valve being controlled in front of the furnace; mechanical stirring is not adopted, as it is considered that the intelligent interest and co-operation of the workman is retained more effectively when his whole attention is demanded in this important operation.

Actually in the cases of the selected workmen who are engaged, a very keen interest is shown in the quality of the product. Their quickness in detecting the presence of accidental impurities by the surface and fracture of the alloys is remarkable. The value of the intelligent co-operation of the operators in the production and refining of white metals is as marked as in any of the skilled industries.

In conclusion the authors desire to express their thanks to Mr. John Fry, of Fry's Metal Foundry, for permission to present this paper and for facilities in its preparation.

CARBON SUBOXIDE.—The combustion reactions into which carbon dioxide CO_2 and carbon monoxide CO enter are so important for the engineer that it may interest him to know that the existence of a carbon suboxide C_3O_2 is now considered established, although such a compound would belong to organic chemistry rather than to inorganic chemistry, and thus hardly concern the engineer. According to Erwin Ott and Karl Schmidt (*Berichte Deutsch. Chem. Gesellschaft*, page 2126, 1922) the suboxide is best prepared from diacetyl tartaric acid anhydride in a rather novel way. The vapours are passed through fine, hot platinum wires, mounted like a tungsten filament in zig-zag fashion on a glass frame. The sub-oxide is a colourless liquid of a formula OC : C : CO which easily decomposes unless kept in a sealed tube in the dark. Diels, who had first prepared this suboxide, and others, had stated that it turned into a brownish or black-red mass, probably by polymerisation; it would now appear that this polymerisation product is not free of phosphorus, phosphorus pentoxide being used in the preparation. The very unpleasant smell attributed to C_3O_2 also seems to be due to impurities.

MOULDING SANDS.

*An Investigation on the Factors Influencing the Grain and Bond in Moulding Sands.**

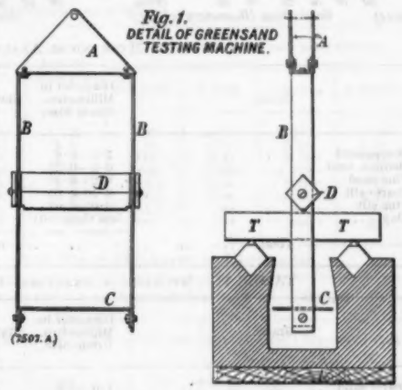
By C. W. H. HOLMES, *B.Met.*

THIS investigation was undertaken with a view to estimating quantitatively the effect upon the essential properties of the sand of the various processes to which moulding sands are subjected. The essential properties that fall within the scope of this research are: (*a*) the strength of the bond; and (*b*) the ratio of the various mechanical grades, which is the determinant of the venting properties of the sand. Whilst refractoriness is undoubtedly a factor of the greatest importance, even in sands for grey iron castings, it is obviously so slightly affected by the method of preparation, or any of the conditions here investigated, that it will not be discussed in this research.

Description of Apparatus.—(*a*) The mechanical tests were carried out on a machine specially constructed for the purpose with a view to applying small loads, of the order of a few hundred grammes, with an entire absence of shock, and at a definite rate in grammes per second. The machine consists of a beam 12 in. long, resting in its centre upon steel knife edges, and having similar knife edges at either end which work in hardened steel shackles. From one shackle is suspended a vessel capable of holding 2 litres of water; from the other an arrangement, as shown in Fig. 1, is suspended. This consists of two triangular pieces of mild steel, A A, connecting the two side pieces, B B, to the shackle. The side pieces support either the breaking bar D in the transverse test, or a flat plate in the compression test; and the tray C, which carries weights to balance, approximately, the weight of water on the opposite arm. The position of the transverse test-bar is shown at T.

For the transverse test two square bars are set in a wooden frame, parallel to the breaking bar and equidistant from it, having their centres 4 in. apart; in

Fig. 1.
DETAIL OF GREENSAND TESTING MACHINE.



making compression tests a flat plate is laid over these bars and the piece is crushed between this plate and another plate fixed between the side pieces in place of the transverse breaking bar. Sufficient water is run into the vessel to overbalance the weights on the tray C, &c., and the test-piece is placed in position.

Water is now syphoned gently out of the vessel until the beam is floating. A measuring cylinder is then placed under the syphon, and water is allowed to run from the vessel to the cylinder by means of a spring-clip until the test-piece fails; the spring-clip is immediately shut off and the volume of water in the measuring cylinder gives directly the breaking stress on the bar in grammes.

The transverse bars are rammed up in a hard-wood core-box with loose sides and loose recessed ends 6 in. by 1½ in. by 1 in., and compressed by means of a wooden top piece having a projection 6 in. by ½ in. by 1 in. to the final size 6 in. by 1 in. by 1 in. The compression pieces are made in a brass boss 1½ in. high, having a ¾-in. round hole in the centre, and are compressed by means of a small screw press and a ¾-in. plunger to 1 in. high by ¾ in. diameter. They are then readily pushed from the boss.

(*b*) Mechanical grading was effected by means of a rotary shaking machine for deflocculating the sample, a Crook's elutriator, and a set of metric copper sieves with punched holes as prescribed by the Institute of Mining and Metallurgy.

The elutriator is of the standard Crook type and dimensions for separating the sand grade, 1 mm. to 0·1 mm.; silt grade, 0·1 mm. to 0·01 mm.; and clay grade, less than 0·01 mm. An additional jet is used for separating the fine and coarse silt, dividing at 0·05 mm. The following refinements have been found essential in work where considerable accuracy is required.

The water, during cold weather, is passed through a glass coil in a bath of warm water, and then through a bottle containing a thermometer, so that all tests may be made using water at 15 deg. C. The sand-grade tube is clamped rigidly in an absolutely vertical position to prevent the coarse silt sliding down and being estimated as sand grade. The rubber tube connecting the constant pressure head and the sand-grade tube has, with the exception of 2 in. of rubber, been replaced by glass. This was done to avoid the errors caused by

* Abstract of a paper read at the meeting of the Iron and Steel Institute, York, on September 5, 1922.

pieces of flocculent material being washed off the inside of the rubber and causing trouble in the elutriator; also, should the water pressure fail during a test, sand falls back into the rubber tube, sticks to this degraded surface, and is lost so far as the test is concerned.

For the bond absorption test a rotary shaking machine has been made. It consists of a wooden disc 1 in. thick and 1 ft. 3 in. diameter mounted on a central spindle, and worked by a friction drive direct from the shaft of a ½ h.p. motor. The rotating speed is 50 r.p.m., and the machine is so arranged that one, two, or three bottles may be rotated at once without unbalancing the disc.

The mill used for milling the sand is an edge runner of the usual type, and of the following dimensions:—Diameter of pan, 6 ft.; diameter of rollers, 3 ft. 6 in.; width of roller faces, 12 in.; weight of rollers, 6 cwt.; speed of pan, 25 r.p.m.

One of the rolls is plain and the other toothed; two distributor plates are fitted to bring the sand under the rollers. The disintegrator is of the horizontal type, the disc 24 in. diameter and the speed 750 r.p.m. No special apparatus was used in the casting experiments; such as was used is described further on.

Methods Employed.—After many experiments in ramming up test-bars of sand the most consistent results were obtained by tempering the sand to a moisture content of 7·5 per cent. and ramming up a definite weight of sand by means of the following standardised series of operations.*

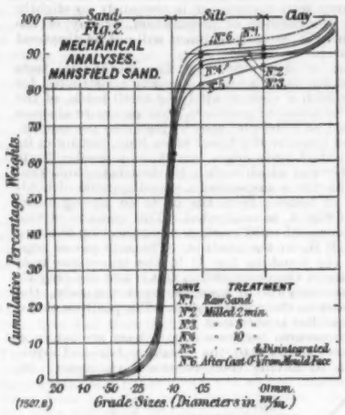
For the transverse test, 180 grammes of sand were taken; the sand was filled lightly into the assembled core-box until level with the top and pressed down by 10 light strokes with a spatula handle. The remainder of the sand was filled in and the process repeated. The top was then placed in position, pressed down by hand, and driven home by 10 strokes of a hand hammer.

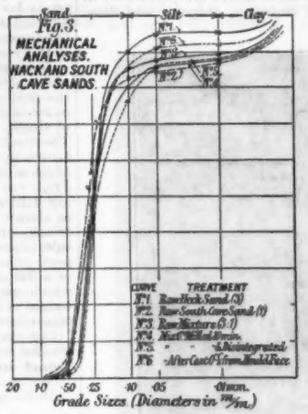
The compression pieces were made by compressing 8 grammes of sand to the required volume in the mould by means of a screw press.

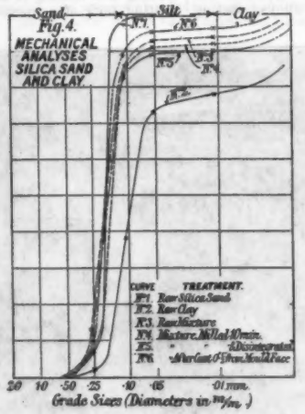
Stronger bars than those used in these tests can be made by increasing the weight of sand per unit volume of the test-bars; they have not, however, given such reliable results as have the bars prepared in the above manner. The use of a small pneumatic squeezer is under consideration as a refinement of the above method.

The silt grade was elutriated into two grades, 0·10 mm. to 0·05 mm. and 0·05 mm. to 0·01 mm., after removal of the sand grade from the lower vessel by means of a different head and jet, working at 27·5 cub. cm. per 100 seconds. The bulk of the water was decanted from all grades, which were subsequently dried at 110 deg. C. and weighed. The sand grade was then divided on the sieves and the fractions weighed.

The bond absorption test was carried out after the method of Hanley and Simmonds. From 10 to 20 grammes of sand, depending on the bond, were weighed into a 500 cub. cm. stoppered bottle and rotated for an hour with 250 cub. cm. of distilled water and 5 cub. cm. of 10 per cent. ammonia. A solution of acetic acid, of such strength that 5 cub. cm. rather more than neutralised the ammonia, was added, and sufficient crystal violet dye (to give at least 40 milligrammes excess after adsorption) dissolved in 100 cub. cm. of distilled water. Any dye remaining in the beaker was rinsed into the bottle with 40 cub. cm. of water (making a total volume of 400 cub. cm.), and the bottle shaken for a further two hours. After standing for some hours, 100 cub. cm. of the clear liquid was drawn off, 2 cub. cm. of 10 per cent. acetic acid and 25 cub. cm. of water added, and the excess of dye was removed by introducing a 5-gramme hank of mordanted cotton yarn, the temperature being gradually







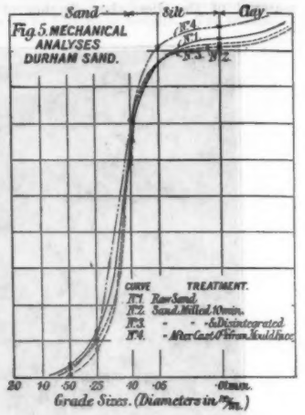


TABLE I.—Mechanical Analyses—Mansfield Sand. (Fig. 2.)

Grade.	Diameter in Millimetres. Grade Size.	Raw Sand.	Milled 2 Min.	Milled 5 Min.	Milled 10 Min.	And Disintegrated.	After Cast. 0"–¼".
Coarse sand	1·0 –0·5	0·50	0·55	0·50	0·50	Nil	0·30
Medium sand	0·5 –0·25	2·43	2·00	2·30	1·80	2·20	3·90
Fine sand	0·25–0·10	70·77	69·65	64·00	63·50	59·80	66·20
Coarse silt	0·10–0·05	16·70	17·15	20·80	21·10	19·50	21·80
Fine silt	0·05–0·01	1·27	1·80	2·00	2·20	5·00	1·60
Clay	less than 0·01	8·33	8·85	10·40	10·90	13·50	6·20
Total		100·00	100·00	100·00	100·00	100·00	100·00

TABLE II.—Mechanical Analyses—Heck and South Cave Sands. (Fig. 3.)

Grade.	Diameter in Millimetres. Grade Size.	Raw Heck.	Raw S Cave.	Raw Mixture.	Milled 10 Min.	And Disintegrated.	After Cast. 0"–¼".
Coarse sand	1·0 –0·5	1·40	5·50	2·90	1·50	0·70	1·80
Medium sand	0·5 –0·25	43·60	51·20	45·70	41·00	40·40	47·60
Fine sand	0·25–0·10	45·35	26·05	36·70	37·50	35·00	36·00
Coarse silt	0·10–0·05	4·25	2·20	2·50	6·30	9·80	5·45
Fine silt	0·05–0·01	0·50	1·75	1·30	1·30	2·00	1·45
Clay	less than 0·01	4·90	13·30	10·90	12·40	12·10	7·70
Total		100·00	100·00	100·00	100·00	100·00	100·00

TABLE III.—Mechanical Analyses—Silica Sand and Clay. (Fig. 4.)

Grade.	Diameter in Millimetres. Grade Size.	Silica Sand.	Clay.	Raw Mixture.	Milled 10 Min.	And Disintegrated.	After Cast. 0"–¼".
Coarse sand	1·0 –0·5	Nil	0·40	0·65	0·60	0·15	0·50
Medium sand	0·5 –0·25	7·60	1·45	12·45	6·80	11·90	10·00
Fine sand	0·25–0·10	91·20	36·55	72·90	77·20	72·25	79·00
Coarse silt	0·10–0·05	1·00	34·70	7·10	6·70	4·90	6·30
Fine silt	0·05–0·01	0·20	5·40	1·00	1·10	1·10	0·70
Clay	less than 0·01	Nil	21·50	5·90	7·60	9·70	3·50
Total		100·00	100·00	100·00	100·00	100·00	100·00

The samples were prepared for elutriation by taking 10 grammes of the sample, previously dried at 110 deg. C., and passing it through a 1 mm. sieve. Any residue remaining on the 1 mm. sieve was examined and any grain aggregates were crushed between the fingers and returned to the sieve; any final residue on this sieve was weighed.

The sample sieved to 1 mm. was transferred to a 500 cub. cm. stoppered bottle, 250 cub. cm. of water, and 5 cub. cm. 10 per cent. ammonia added, and shaken for an hour on the rotary shaking machine in order to deflocculate the clay. Eight to 10 litres of water were usually found to be sufficient to remove the clay grade from the elutriator, which was collected in litre-graduated cylinders (this afforded a running check on the rate of elutriation, which was kept steady at 100 cub. cm. in 90 seconds), and allowed to settle out in Winchester bottles. Five minutes before the end of the test, the clip between the sand and the silt vessels was partially closed to avoid the coarse silt running back into the sand vessel. In the case of a sand such as Mansfield, where a large percentage of the grains vary between 0·15 mm. and 0·08 mm., this precaution is very necessary.

TABLE IV.—*Mechanical Analyses—Durham Sand.* (Fig. 5.)

Grade.	Diameter in Millimetres. Grade Size.	Raw Sand.	Milled 10 min.	And Disintegrated	After Cast. 0"–¼".
Coarse sand	1·0 –0·5	3·00	2·45	0·50	1·75
Medium sand	0·5 –0·25	8·55	5·30	6·40	8·35
Fine sand	0·25–0·10	53·45	51·85	52·35	60·50
Coarse silt	0·10–0·05	21·20	25·85	28·00	20·80
Fine silt	0·05–0·01	7·75	7·10	4·55	5·75
Clay	less than 0·01	6·05	7·45	8·20	2·85
Total		100·00	100·00	100·00	100·00

TABLE V.—*Grade Chemical Analyses—Mansfield Sand.*

Grade.	Fine Sand.	Coarse Silt.	Clay Grade.
SiO_2	85·96	74·74	37·26
Fe_2O_3	1·24	0·94	3·44
Al_2O_3	6·26	7·28	18·32
CaO	1·54	4·23	15·58
MgO	0·90	2·47	2·10
K_2O	1·14	2·42	2·85
Na_2O	0·12	0·18	0·15
Loss on ignition	3·04	7·40	20·70
Total	100·20	99·66	100·40

TABLE VI.—*Grade Chemical Analyses—Heck and South Cave Sands.*

Grade.	Raw S. Cave. Bulk Analysis.	Raw Heck. Bulk Analysis.	Mixture Medium Sand.	Mixture Fine Sand.	Mixture Clay Grade.
SiO_2	85·68*	87·20	92·38	89·48	28·42
Fe_2O_3	5·68	1·75	0·56	1·60	9·80
Al_2O_3	4·30	5·23	3·36	4·58	13·78
CaO	0·24	0·20	trace	0·06	17·20
MgO	0·26	0·28	0·20	0·34	1·41
K_2O	0·48	3·04	1·85	1·73	4·62
Na_2O	0·18		0·21	0·28	0·24
TiO_2	0·15	N.D.	N.D.	N.D.	N.D.
Loss on ignition	2·48	1·45	1·08	1·30	24·00
Total	99·45	99·15	99·64	99·37	99·47

* R. J. Doty, "Proceedings of the American Foundrymen's Association, 1922," records the fact that volumetric methods for the measurement of sand for test-bars have been superseded by gravimetric methods, and more concordant results have been obtained thereby

* Professor Boswell, "Memoir on Refractory Sands," Part I., gives 0·36 per cent. P_2O_5 due to glauconite in this sand.

raised to 60 deg. C. After the whole of the dye had been removed from the solution, the yarn was withdrawn, washed, and dried at 75 deg. C. This hank was then compared with a series of similar ones, on each of which a standard weight of dye had been deposited. From this the weight of dye adsorbed by the bond of the sand is calculated.

The analyses were made on 0·5 gramme of the finely ground sample. Loss on ignition was determined, and a fusion effected by heating the residue with 5 grammes of fusion mixture.

Silica was separated by two extractions; the yield of silica obtained on taking the filtrate from the first residue to dryness being usually of the order of 0·6 per cent.

TABLE VII.—*Grade Analyses—Silica Sand and Refractory Clay.**

Grades.	Bulk Analysis. Silica Sand.	Clay. Fine Sand.	Coarse Silt.	Fine Silt.	Clay Grade.
SiO_2	88·30	91·12	82·50	68·58	45·48
Fe_2O_3	1·74	0·22	0·62	1·74	1·24
CaO	2·66	0·16	0·52	1·84	8·86
Al_2O_3..	1·48	5·44	9·44	15·78	22·32
MgO	0·96	0·11	0·36	0·71	1·35
K_2O	0·42	1·06	1·54	2·16	3·08
Na_2O	0·35	0·31	0·47	0·38	0·44
TiO_2†	N.D.	N.D.	N.D.	N.D.	N.D.
Loss on ignition ..	4·64	1·32	2·68	6·90	15·40
Total	100·55	99·74	98·13	98·09	98·17

TABLE IX.—*Loss on Ignition per Cent.*

Sand.	Before Casting	Distance from Mould Face after Casting. 0–½ in.	1 in.	2 in.	4 in.
Mansfield	4·82	3·25	4·78	4·83	4·85
Heck and South Cave	2·40	1·55	2·15	2·30	2·36
Sand and clay ..	4·52	3·14	4·31	4·40	4·63
Durham	2·15	1·25	1·95	2·16	2·16

TABLE XII.—*Bond Distribution Factor.*

$$= \frac{\text{Strength of Transverse Bar} \times 100}{\text{Bond Adsorption Value.}}$$

Sand.	Raw.	Milled 2 Min.	Milled 5 Min.	Milled 10 Min.	And Disintegrated
Mansfield	8·0	12·1	13·9	13·1	13·8
Heck and South Cave	7·3	N.D.	N.D.	22·8	23·3
Sand and clay ..	Nil.	N.D.	N.D.	8·6	9·0
Durham	11·9	N.D.	N.D.	15·3	15·2

TABLE XIII.—*Grade Analyses—Durham Sand.*

Grade.	Sand.	Silt.	Clay Grade.
SiO_2	94·20	80·35	50·20
Fe_2O_3	1·24	3·18	5·34
Al_2O_3	3·05	8·56	21·54
CaO	0·15	0·60	2·26
MgO	0·20	1·24	5·12
Alkalies	1·04	1·95	4·77
Loss on ignition ..	0·40	4·35	10·84
Total ..	100·28	100·23	100·07

Iron, alumina, titanium, and phosphorus were separated by precipitation on ashless pulp fibres with ammonia. From the weighed residue, iron was estimated by stannous chloride and di-chromate, and the alumina as phosphate. Lime was precipitated as oxalate and estimated volumetrically with permanganate. Magnesia was weighed as the pyro-phosphate. The alkalies were determined by the Lawrence-Smith method, and separated by perchloric acid.

The casting tests were made in the following manner: Three circular moulding boxes, each 4 in. deep and 1 ft. 6 in. in diameter, were taken. One of them was rammed up with floor sand and dried; over this was placed a disc of 30-mesh iron gauze, 18 in. diameter, having a 3½-in. hole in the centre.

A second box was placed upon the gauze and rammed up with the sand under investigation round a cylindrical pattern 8 ft. long, 3 in. diameter, placed in the centre of the box. A good joint having been made, straight wires of tin, lead, zinc, aluminium, and silver, each exactly 6 in. long, were laid radially along the joint and touching the pattern, filling an angle of 60 deg. The third box was now put on, rammed up, the position of the wires marked on the box, and the metal was poured into the green-sand mould. The object of the dry-sand drag and the wire gauze covering was to provide a solid foundation for the mould without risk of contamination of the sand whilst on the foundry floor, or whilst taking the samples of sand from the mould after casting.

* The grade analyses refer to the clay only and not to the mixture of sand and clay.

† Owing to lack of time the titanium was not determined. Professor Boswell, "Memoir on Refractory Sands," page 136, gives 1·85 per cent. TiO_2 in a bulk analysis of this seam of clay.

The samples of sand were taken, after the mould had cooled down, as follows:

The sand up to half an inch from the face of the casting was isolated by pressing down through the sand a cylinder of tinned sheet. About 90 deg. of the cylinder was cut away, and ½-in. of edge turned in at each side, so as not to cut the wires. The samples at 1 in., 2 in., and 4 in. from the face of the mould were taken by means of a tinned sheet tube 1 in. in diameter.

When all tube samples were taken and transferred to their respective tins the casting and sheet metal casing were removed, the sand transferred to its container, the wires carefully dug out, and the length over which they had melted was measured.

"South Cave Red." It is dark brown in colour, and has, especially when its mechanical analysis is considered, a most remarkable bond. The peculiar stickiness of this sand is quite unique in the author's experience of English moulding sands. It is apt to be nodular and is not easy to sample accurately. Its chemical composition is sufficiently good to permit of its use as a bonding material in steel moulding. The mixture of Heck and of this sand is used, mixed with an equal amount of old sand, as a facing sand for green-sand work with great success. It occurs in the Jurassic System (Kelloway Beds).

The silica sand is a second-grade sand of unknown origin, and is normally used solely in the making of "oil-sand" cores.

TABLE VIII.

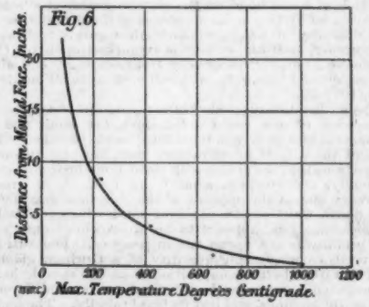
	Raw.	Milled 2 Min.	Milled 5 Min.	Milled 10 Min.	And Disintegrated.	Distance from Mould Face. 0–½ Inch.	1 Inch.	2 Inches.	4 Inches.
Mechanical Tests—Mansfield Sand.									
Transverse	92·5	145·5	167	162·5	170	120	158	173	163
Compression	580	634	850	895	870	470	610	700	870
Mechanical Tests—Heck and South Cave. 3:1 Mixture.									
Transverse	89	N.D.	N.D.	375	420	78	250	238	355
Compression	375	N.D.	N.D.	1,230	1,280	360	700	750	1,190
Mechanical Tests—Silica Sand and Clay. 5:1 Mixture.									
Transverse	Nil	N.D.	N.D.	55	63	Nil	55	58	60
Compression	Nil	N.D.	N.D.	200	195	130	180	220	220
Mechanical Tests—Durham Sand.									
Transverse	38	N.D.	N.D.	55	55	16	36	45	60
Compression	100	N.D.	N.D.	190	185	120	165	165	190

TABLE X.—BOND ADSORPTION VALUES.
(Milligrammes of Dye per 100 Grammes of Sand.)

Sand.	Raw.	Milled 2 Min.	Milled 5 Min.	Milled 10 Min.	And Disintegrated.	Distance from Mould Face after Casting. 0–½ Inch.	1 Inch.	2 Inches.	4 Inches.
Mansfield	1,160	1,200	1,200	1,240	1,240	680	1,240	1,240	1,220
Heck	540	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
South Cave	2,860	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Heck and South Cave	1,220	N.D.	N.D.	1,640	1,800	680	1,560	1,735	1,760
Silica sand	Nil	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Clay	3,600	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Sand and clay	700	N.D.	N.D.	640	700	240	620	660	700
Durham	320	N.D.	N.D.	360	340	110	260	320	320

TABLE XI.—VALUES SHOWN PER 1 PER CENT. CLAY GRADE SEPARATED IN ELUTRIATOR

Sand	Mansfield.			Heck and South Cave.			Sand and Clay.			Durham.		
Treatment	Raw.	Prepared.	Cast.	Raw.	Prepared.	Cast.	Raw.	Prepared.	Cast.	Raw.	Prepared.	Cast.
Clay Grade	8·38	15·40	6·20	6·20	12·10	7·70	5·90	9·70	3·50	6·05	8·20	2·85
Transverse strength per 1 per cent. clay	11·20	11·05	19·40	15·10	34·50	10·10	—	6·50	—	6·30	6·71	5·60
Compressive strength per 1 per cent. clay	69·5	56·8	75·5	34·4	106·0	46·7	—	20·10	37·0	26·5	23·2	42·1
Bond adsorption per 1 per cent. clay	139·0	80·5	110.0	112·0	149·0	88·0	119·0	72·0	68·5	52·5	41·4	38·6
Loss on ignition per 1 per cent clay..	0·575	0·314	0·525	0·220	0·198	0·202	0·765	0·465	0·895	0·355	0·262	0·438



Origin and Nature of the Sands Used in the Investigation.—The Mansfield sand used was the variety known as "best moulding," and was obtained from the pits unmilled. Consecutive consignments of this sand have shown great regularity in grain, size, and bond. It is typical of the best Bunter moulding sands, combining good venting properties with a fine grain and an excellent bond; also it is more refractory than many of the Bunter sands, being less micaceous. In addition it possesses that "silky" texture which gains the confidence of the moulder, a matter of prime importance.

The Heck sand also occurs in the lower Bunter formation, but is more comparable to the Worksop deposit or to the coarser beds overlying the Mansfield "moulding sand." It is reddish-orange in colour and contains a fair amount of Muscovite.

The South Cave sand was the variety known as

The refractory clay used in the "silica sand and clay" mixture was obtained from the Yorkshire Amalgamated Products Limited's sand pits between Castle Howard and Huttons Ambo. These beds lie in the Lower Oolites, and the clay is found overlying well-defined beds of high-silica and kaolin-bearing silica sands of considerable purity, and of widely differing mechanical characteristics. It would be more correctly classed as a strong loam than as a clay. As will be seen from the bond adsorption figure, the clay grade is very "fat"; much more so than the kaolin bonding the sands beneath it. Unfortunately only sufficient was available for one test, which was made by adding the clay, ground dry, to the sand in the mill, and tempering during milling. Had more been available, a second trial would have been made, adding the clay as a slip, which would probably have been more successful. In any case, the coating of smooth grains of silica with clay by mechanical means is a difficult and unsatisfactory proposition.

The Durham sand is of glacial origin. Both as considerable deposits and in isolated pockets, these sands are widely distributed in County Durham. The author has examined many samples varying from coarse bondless sands to silty loams containing up to 20 per cent. of clay grade. Whilst they appear to be quite useful from the bulk analysis, they are almost usually badly sorted as regards mechanical grading, and consequently vent poorly. The bond is composed of a rather lean clay which burns out quickly, and the sand has a strong tendency to burn on to the casting. These glacial sands are widely used in the Tyne-Tees area, and their continual deficiency of bond is made good by additions of Erith or similar loam. The author believes, as regards the above district, that more defective castings are attributable to this practice than to any other single factor.

Consideration of the Results Obtained.—Amongst the new data presented in this report there is much that is

difficult to interpret; there are also points upon which it is unwise to be dogmatic in view of the lack of data upon moulding sands in general. Some, however, of the results obtained afford new and quantitative data which should be of service to the ironfounder.

Examination of the mechanical analyses show a considerable and progressive degradation of grain size during the preparation of the sand. This degradation becomes more considerable when it is borne in mind that in practice the sand is milled several times during its useful life, and that the increase in grain size, which, contrary to expectation, was observed in each case after casting, must be apparent only, and due to causes which will be discussed later.

The mechanical analyses of Mansfield sand, Heck and South Cave sands, silica sand and clay, and Durham sand are given in Tables I to IV, and are illustrated in Figs. 2 to 5; whilst Tables V to VII give the grade chemical analyses of Mansfield, Heck and South Cave sands, and silica sands and refractory clay.

Table VIII gives the mechanical test results of the various sands; Tables IX to XIII show respectively loss on ignition, bond adsorption values, the values per 1 per cent. of clay grade separated in the elutriates, the bond distribution factor, and the grade analyses of Durham sand.

The Mansfield series (Fig. 2 and Table I) is the most complete, and, as each curve is the mean of at least two elutriations, it is probably the most accurate. It is also the most easily interpreted. This sand, being fine grained, has a large surface over which the bonding matter must be spread, hence it is fair to assume that this coating is thin enough to be affected almost throughout its depth before milling by the process of deflocculation, even though it may not be entirely removed from the enclosed sand grain. This contention is strongly supported by the comparatively slight increase in the bond adsorption value on milling the sand. Considerable light is thrown upon the high mechanical strength of the sand, and on the increase of strength on mechanical treatment by examination under a good hand lens × 7, and a low-power microscope × 35.

In the raw state the sand is seen to contain many clusters of grains which hold more than the average quantity of bonding material—and apparently the bulk of the fine silt as well—leaving less than the average amount for distribution over other grains; the points of contact between these latter grains being the weak link in the chain. Even after an hour's deflocculation and two hours in the elutriator, the grains retain their red tint due to a very thin pellicle of ferric oxide, which, in view of its resistance to solution in hydrochloric acid, would appear to be dehydrated and incapable of adsorbing dye.*

The bond then would seem to exist in two forms:—

(1). The mobile or hydrated bond which is capable of transference from grain to grain, and (2) the static bond which is fixed to the surface of the sand grains, forming a hold upon which the mobile bond may be evenly spread and displayed to the best advantage for mechanical strength. This static bond, common to all Bunter moulding sands that the writer has examined, although small in amount, certainly has a greater tendency to strengthen the sand than would a similar amount of mobile bonding material coupled with smooth grains of silica.

Alongside the grain degradation there occurs a consistent increase in the amount of clay grade separated; it is the most striking series of increases of all the grades, and is sufficiently large to be readily detected by the elutriator without the refinements adopted in this investigation. Bearing in mind that only a slight increase occurs in the bond adsorption value, it follows that practically the whole of the mobile bonding material must have been acted upon in the raw sand; consequently it would be expected to be removed in deflocculation without having to be rubbed off by the edge runner and disintegrator.

On the other hand this increase in the clay grade may have been produced by the mechanical reduction of sand to silt, and of silt to clay grade. The lower value of 1 per cent. clay grade in the prepared sand is evidence which strongly supports this latter theory.

It seems very probable that both factors have contributed an indeterminate share and also that the considerable attrition has removed a portion of the static bond, which, being of little use as mobile bond and having a low bond value, would naturally lower the value per unit of clay grade after preparation. The apparent increase in coarseness after casting is seen, on visual examination, to be due to the fritting of silt and clay around the sand grains and enlarging them. The loss of clay grade is a natural sequence of this. These aggregates are not broken down (although possibly to a small extent) by deflocculation; but treatment with hot hydrochloric acid causes separation in all but extreme cases taken from the mould faces.

The acid-cleaned silica grains from the face of the mould were opaque after casting, apparently due to internal cracking; and the bond on the uncleaned sand was bleached to a light grey, fading off through half an inch of pinkish sand to the original colour. This bleaching seems to be more of a physical than a chemical (reduction of ferric oxide) change, as the yellow ferric ions were noticeable at once on pouring acid on the sand in a test tube. On re-milling the used sand, a further portion of the fine silt and clay grades will be removed from the silica grains, and these, together with silt grade produced by the breaking down of the cracked grains referred to above, will gradually accumulate and yield a high content of silt-grade, such as is almost invariably found in floor sands which have seen much service.

There is a double disadvantage involved in the use of sand of high fine silt content: firstly, the porosity of the sand is seriously impaired, and secondly, the large surface displayed calls for a high clay content to cover it efficiently. The mixture of Heck and South Cave sands is the result of a successful attempt to imitate the good qualities of Mansfield sand in a coarser grain. In making up this mixture, South Cave sand was selected as having those properties which the writer has found to be essential in bonding materials for iron moulding sands in an unique degree, namely:—

(*a*) A high content of fairly pure sand grade of considerable uniformity of grain size and possessing statie bond.

(*b*) A low content of silt grade.

(*c*) A fairly high content of clay grade, exceedingly "fat" as shown by the dye adsorption value, of considerable permanence, as shown by the figures obtained from the "after cast" samples, and having a better chemical grade analysis than is really needed for this class of work (*vide* Mansfield clay grade).

(*d*) A high content of ferric oxide, which in the writer's opinion has a very great influence upon the skin of the castings produced.

The ideal diluent for South Cave must have a very high content of sand grade of similar grain size, must possess static in preference to mobile bond, and be low in silt and clay content. It should preferably contain ferric oxide in the static bond and must, of course, be of reasonably good analysis. In this matter Mansfield sand was rejected as being too fine in grain and carrying too much coarse silt, which, harmless in the fine-grained Mansfield, where microscopic measurement has shown the bulk of the grains to lie between 0·14 in. diameter and 0·08 in. diameter, would seriously impair the venting properties of a more open sand. Also the high bond carried is not needed.

Worksop sand was too fine in grain size, otherwise it would have been quite suitable. In Heck sand all the requirements are fulfilled.

Examination of the results shows that a large increase both in bond value and in mechanical strength occurs on milling and disintegration. When it is considered that the bulk of the bond is distributed, in a rather nodular state, over one-quarter of the sand, and that this has to be distributed over the remaining three-quarters, this increase is not surprising. The bond distribution factors tend to show, however, that the limit of useful milling has been reached.

The dye adsorption values show an increase which is much more considerable than had been expected; evidently deflocculation is not violent enough to reduce the strong clay nodules to a fine state of division.

Unit clay grade shows a higher value after milling, in comparison with that before, than in any of the other sands, and this lends support to the suggestion that useful mobile bond is progressively displayed as milling proceeds, to such an extent as to overcome the diluting effect of detrital matter resulting from degradation of sand and silt. The permanence of the bond is satisfactory, though not so good as in the Mansfield sand; it would seem to be affected by temperatures below 200 deg. C. to a greater extent than the Mansfield bond, and this may be due to the South Cave bond being less ferruginous and more argillaceous than the bond in the Mansfield sand.

The values obtained in the tests on the silica sand and clay mixture are not of very great value; the clay was added dry and in size smaller than 10-mesh, tempering being effected during milling; pellets of clay were present even in the disintegrated sand, giving poorer tests than should have been obtained, and rendering accurate sampling impossible.

The fact that the raw mixture was too weak to give any mechanical tests also detracts from the value of the series. The detrimental effect upon bond distribution of the lack of static bond on the smooth grains of silica is accentuated by the modified success of the series of tests. The difficulty of coating smooth silica grains with clay is, however, well known; it is remarked upon by Dr. Moldenke in his "Principles of Ironfounding," and also in a paper read before the Institution of British Foundrymen, 1919–20.

The author has succeeded in carrying out the successful mixing of new well-bonded sand, old sand, and a proportion of a poorly bonded local sand, together with a small quantity of fat refractory clay, but only in such proportions that the grains with static bond predominate.

Finally, the Durham sand is an instance of great interest; almost the opposite of the Mansfield and Heck and South Cave sands. It is a sand which, on bulk chemical analysis, appears to be an excellent one, yet this promise is not borne out in practice. The author has used a considerable quantity of a Durham glacial sand of rather better composition than the sample here investigated; it vented badly, produced an indifferent skin on the castings, and lost its bond rapidly. The facts here demonstrated go far to explain this apparent contradiction between theory and practice; on examining the bond adsorption values it is evident that the sand is bonded with a rather lean clay which is not nearly so permanent as is that of the Bunter sands.

As regards the appearance of the castings produced from the test moulds, which were not blacked nor protected in any way, the casting from the Mansfield test had an excellent smooth blue skin which was only slightly better than that obtained with the Heck and South Cave mixture. The standard clay mixture came out with a loose scale of sand and minute pellets of burnt clay, which was rather reminiscent of a steel casting from a "compo" mould.

The Durham sand gave a greyish blue skin, rather rough owing to burning on.

Whilst the refractoriness of these sands is not one of the subjects under investigation, the writer feels that it is not out of place to suggest that the ferric oxide content of moulding sands for grey-iron founding will one day, when the matter is fully investigated, be classed as a factor of prime importance. Although no evidence can be brought at the moment to support such a theory, it may be that in the presence of ferric oxide, a smooth blue skin of Fe_3O_4 is formed in preference to one of high FeO content, and consequently having a smaller tendency to form ferrous silicates with the sand grains. The curve (Fig. 6) showing the maximum temperatures to which the sands were subjected is a mean curve from the four casts, the results from which were practically identical. The mean point for the aluminium wire lies outside the smooth curve; this is due to its higher thermal conductivity. In the absence of a pyrometer, casting temperatures could not be determined, but would be in all cases approximately 1,250 deg. C.

Conclusions.—1. That the mechanical and physical properties of sands for grey-iron founding are of equal importance to the chemical analysis.

2. That the bond adsorption value obtained on the raw sand may be greatly modified by mechanical treatment.

3. That the most successful moulding sands contain both static and mobile bond.

4. That an appreciable degradation of the grains of a moulding sand occurs during the mechanical preparation as usually effected.

5. That the bond distribution factor is a characteristic of moulding sands that is of great importance in view of the excessive degradation which may be caused by prolonging milling beyond the time needed to effect the optimum distribution.

6. That no single test is sufficient on which to judge the practical value of many moulding sands, but a careful consideration of all those tests which have been described above.

The writer wishes to thank Mr. K. C. Appleyard, general manager of the Birtley Iron Company, for having readily granted every possible facility for the conduct of this research. Also Mr. J. Brewis, works manager, for his ready assistance in many details.

* This point is now under investigation in the Laboratory of the Birtley Iron Company.

CATALOGUES.

Carrier Tricycles.—A circular illustrating these vehicles is to hand from the Rapid Carrier Tricycle Company, Limited, 6, Emerald-street, Theobalds-road, London, W.C.1.

Manganese Steel.—A 24-page pamphlet has been issued by Messrs. Edgar Allen and Co., Limited, Sheffield, describing many special uses of manganese steel and the methods of forging and heat treating it.

Lifting Gear.—A 50-page booklet of their cranes, trucks, pulley blocks, jacks and other lifting and conveying gear, with illustrations and prices, has been issued by Messrs. Herbert Morris, Limited, Loughborough.

Crankless Engine.—A catalogue describing the rotary engine with swash plate and pistons, dealt with in Engineering, vol. cxi, page 290, has been issued by the Crankless Engines (Aus), Limited, 450, Collins-street, Melbourne.

Electric Fans.—A well arranged leaf catalogue of small fans driven by direct current motors, with price lists for each type, has come to hand from the Triumph Electric Manufacturing Company, Limited, Steward-street, Birmingham.

Waste Heat Boilers.—A description of waste heat boilers, with statements of the economies realised in their operation, has been issued in a special booklet by Messrs. Spencer-Bonecourt, Limited, Parliament Mansions, Victoria-street, London, S.W. 1.

Calorimeters.—Messrs. A. Gallenkamp and Co., Limited, 19, Sun-street, Finsbury, London, E.C. 2, send a copy of a new catalogue containing illustrated descriptions, and price lists of nine different calorimeters, for testing liquid, solid and gaseous fuels.

Tools.—A catalogue of hand and machine tools and instruments, issued by Messrs. George H. Alexander Machinery, Limited, extends to 230 pages quarto. It is fully illustrated, and gives complete dimension tables and prices for nearly all the articles listed.

Air Ejectors.—An improved type of ejector for automatic vacuum brakes, made by the Freins Jourdain Monneret Company, of Paris, is described in a catalogue received from their British agents Messrs. J. F. Wolff & Co., 33, Tothill-street, London, S.W.1.

Machine Mining.—The August number of the journal issued by Messrs. Mavour and Coulson, Limited, 47, Broad-street, Mile-end, Glasgow, continues the firm's policy of giving entirely relevant matters of practical value as to the use of machines in mining.

Electric Light Diffusers.—An illustrated and priced list of light diffusers for gas-filled lamps, made by the Western Electric Company, Limited, North Woolwich, has been issued by Messrs. Lionel Robinson and Co., 3, Staple Inn, W.C. 1, who are the agents for Middlesex and Surrey.

Power Factor Improvement.—The British Insulated and Helsby Cables, Limited, Prescot, Lancashire, have sent us a catalogue explaining and describing their condensers for improving power factor, and point out that considerable economy may be effected even on consumptions as low as that of a 5-h.p. motor. The catalogue gives a good deal of technical information relating to the use of these condensers, and is worthy of careful consideration.